Networks of Liveness in Singer-Songwriting: A practice-based enquiry into developing audio-visual interactive systems and creative strategies for composition and performance.

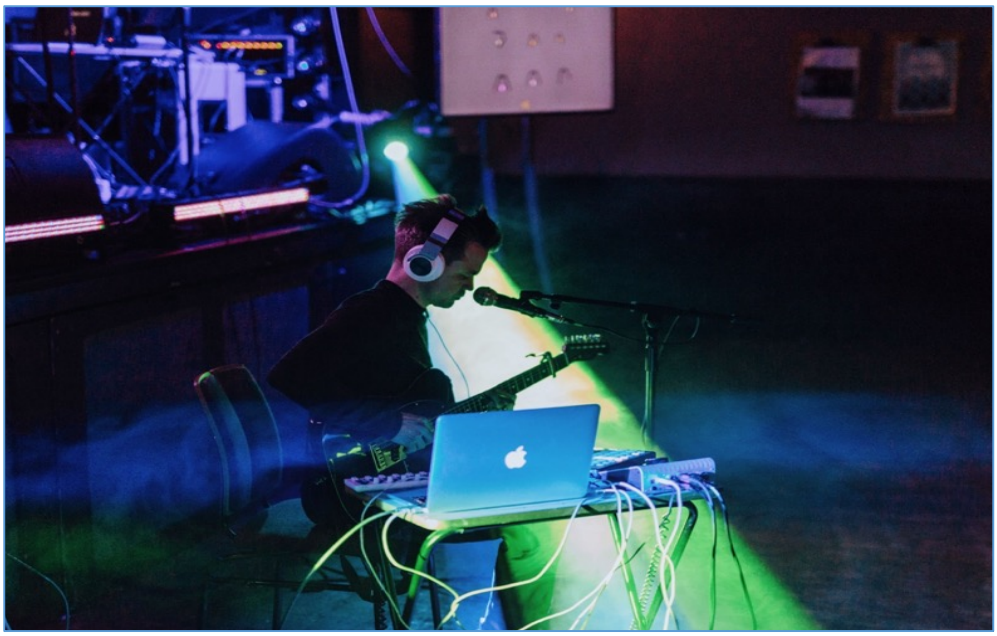

Figure 1: Performance of Church Belles *at Leeds International Festival of Artistic Innovation, 2016. Photo by George Yonge. Used with permission.*

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Abstract

This enquiry explores the creation and use of computer-based, real-time interactive audio-visual systems for the composition and performance of popular music by solo artists. Using a practice-based methodology, research questions are identified that relate to the impact of incorporating interactive systems into the songwriting process and the liveness of the performances with them. Four approaches to the creation of interactive systems are identified: creating explorative-generative tools, multiple tools for guitar/vocal pieces, typing systems and audio-visual metaphors. A portfolio of ten pieces that use these approaches was developed for live performance. A model of the songwriting process is presented that incorporates system-building and strategies are identified for reconciling the indeterminate, electronic audio output of the system with composed popular music features and instrumental/vocal output. The four system approaches and ten pieces are compared in terms of four aspects of liveness, derived from current theories. It was found that, in terms of overall liveness, a unity to system design facilitated both technological and aesthetic connections between the composition, the system processes and the audio and visual outputs. However, there was considerable variation between the four system approaches in terms of the different aspects of liveness. The enquiry concludes by identifying strategies for maximising liveness in the different system approaches and discussing the connections between liveness and the songwriting process.

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Special thanks to John Richards.

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Dedicated to the memories of Jean Miller (1925-2018) and Paul Murfin (1973-2011).

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Portfolio contents

The ten pieces in the portfolio are as follows:

- *Rows, Columns, Collisions*
- *I Begin Where You End*

} 'Explorative-generative' pieces

- *Willow*
- *Unquiet*
- *Brains Need Bodies Too*

} 'Multi-tool' pieces

- *Kafka-Esque*
- *Leave My Room*

} 'Typing' pieces

- *Church Belles*
- *Broken Starling*
- *Piece for Tape*

} 'Metaphor' pieces

Video recordings of live performances of the pieces in the portfolio can be found at: http://www.nationaltrevor.com/music/ [Accessed: 14 September 2018].

Downloads of the Ableton Live sets, Max projects, Max for Live devices and Processing sketches used in this portfolio can be found at: http://www.nationaltrevor.com/downloads/ [Accessed: 25 September 2018].

Scores/lyric sheets for the pieces are included in Appendix 8.3.

All of the above are included with an electronic copy of this document on the USB drive attached to the physical copy of this thesis.

1. Introduction

1.1. Overview, definitions and rationale

1.1.1. Overview

This enquiry explores how interactive systems can be incorporated into singer-songwriter practice as composition and performance partners. Through the creation of a portfolio of systems and compositions (detailed in Chapter 3), it examines the implications for the songwriting process and explores strategies for combining instrumental/vocal and system audio output (Chapter 4). Comparisons between systems and pieces in terms of contemporary theories of liveness are discussed in Chapter 5, before drawing conclusions and making recommendations for further work in Chapter 6. This chapter discusses the key concepts and rationale for working with interactive systems before outlining the research questions, artistic goals and method. Chapter 2 presents a review of relevant theoretical and practical work as a background to the two research questions introduced in Chapter 1.

1.1.2. Interactive systems

Many definitions of interactive music systems do not inherently define a level of interactivity and focus instead on response to human input (Rowe, 1993; Manzo, 2011). Other definitions specify that in order to be interactive, the system must allow human and machine agents to influence each other's behaviour through the iterative exchanging and processing of information (Chadabe, 1984; Noble 2009; Gifford and Brown, 2011). The system may exert an influence over the resulting music through *performative* or *memetic* agency. Performative agency refers to its real-time influence due to a degree of autonomy in performance. Memetic agency, related to Dawkins' (1989) theory of cultural transmission, refers to the

system's influence during composition through idiosyncrasies, errors and the process of system development (Bown et al, 2009). For the purposes of this enquiry, in order to be considered truly interactive, the systems developed were required to reveal both performative and memetic agency and retain a significant element of unpredictability in their audio output.

Interactive music systems typically comprise four groupings of components, as shown in Figure 2:

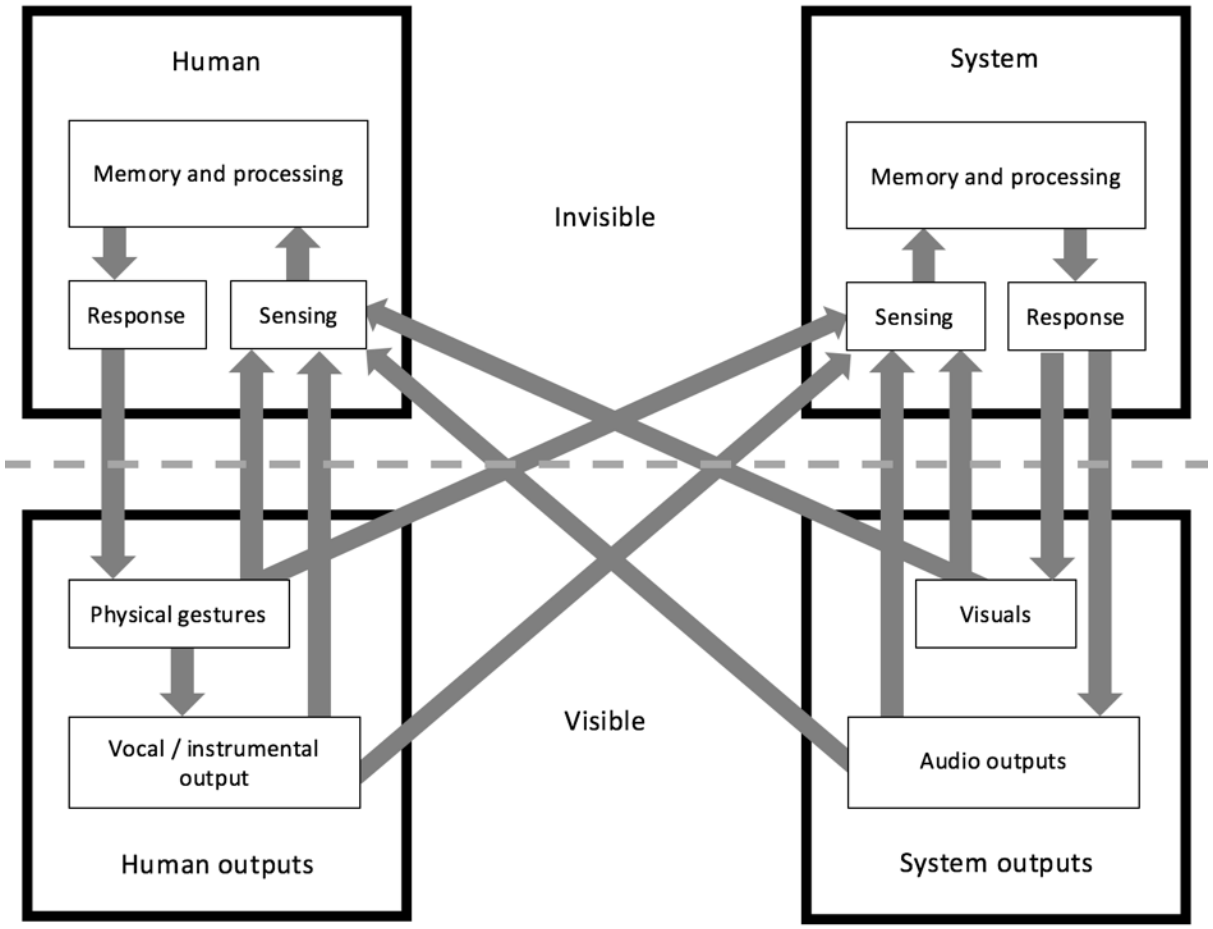

Figure 2: Structure of interactive music systems (after Rowe, 1993; Bongers, 2000; Winkler, 2001 and Drummond, 2009).

Sensing involves the collection and digital conversion of raw performance data (Rowe, 1993; Winkler, 2001). *Memory and processing* converts this data into usable forms such as triggers and parameters (Rowe, 1993; Winkler, 2001) through techniques such as score-following

(Cont, 2008) and machine learning (Caramiaux and Tanaka, 2013; Bullock and Momeni, 2015). These triggers are passed to the *response algorithm* which may play back sequenced material (Sanden, 2013); transform the audio input (Mainsbridge and Beilharz, 2014); influence generative processes (Collins, 2008; Shao et al, 2010) or create novel responses based on human instrumental input through reflexive processes (Pachet, 2006; Biles, 2013). Finally, the *outputs* stage enables the results of these algorithms to be made audible through synthesis, processing of live audio and/or audio file playback. Outputs may also be visual (Johnston et al, 2008; Bown et al, 2014a).

There are several advantages to working with interactive systems. First, they offer the opportunity to work with processes that are outside of the performer's direct control. This can directly lead to new musical directions through the disruption of familiar working practices such as instrumental playing style (Lansky, 2005; Waite, 2014; NPR Music, 2015). Second, the unpredictability of the system audio output and the reduced need for pre-sequenced material makes each performance a unique event for both audience and performer (Wishart, 1994; Cascone, 2002a; Delaney, 2016). Third, they allow the real-time generation of multiple layers of complex material (Eigenfeldt, 2009). As well as audio layers, the use of the visual channel can enhance audience engagement (Sanden, 2013; Berthaut et al, 2014) and provide additional channels of expression (Garro, 2005; Correia et al, 2017). Fourth, the use of interactive systems enables performers to interact with real-time processes, allowing artworks to potentially represent the world in open, dynamic forms rather than as fixed or static objects (Brown, 1999; Maeda, 2004; Emmerson, 2012b). Fifth, they can be used to explore serial and procedural composition techniques in real-time (Chadabe, 1997; Eigenfeldt, 2007). Sixth, they can be configured to substantially reduce the demands on the live performer, freeing up attention for listening and decision-making (Rowe, 2004). Finally, the ability to run the systems on a laptop, using minimal additional hardware, means that such systems are highly portable (Richards, 2006).

1.1.3. Songwriting and the use of interactive systems

Williams and Williams (2016) define a singer-songwriter as a popular musician who composes and performs their own songs. In this enquiry, due to the complexity in defining popular song (Middleton, 1990), popular songs will be viewed as pieces of music that:

- Have lyrics as a central feature.
- Contain simple, repeating melodic and rhythmic elements.
- Are of less than ten minutes in duration.
- Potentially appeal to a mass audience.

Although singer-songwriting may be seen as an authentic expression of the individual (Jones, 2005), other musicians frequently make significant creative contributions in composition, production and performance (Hennion, 1990; Sanden, 2013). Furthermore, the instruments and creative technologies used are widely acknowledged as agents in the creative process rather than simply tools that an artist has mastery over (Prior, 2009). Interactive systems mirror the agency of human collaborators through their ability to extend a singer-songwriter's instrumental and vocal performance while offering more expressivity and flexibility than pre-recorded backing tracks or commercial looping tools. Where they are granted significant performative and/or memetic agency, they will have a significant impact on the compositions, influencing the singer-songwriter's idiolect in terms of both surface features and features of form (Moore and Ibrahim, 2005) as well as their performance practice (Dezeen, 2016).

Interactive systems offer songwriters myriad creative opportunities through their potential to generate complex patterns of events, produce a wide range of timbres and incorporate real-time visuals. While some electronic musicians have rejected the use of traditional instruments in the pursuit of new paradigms, others suggest that using interactive tools to extend existing practice facilitates an audience's engagement with unfamiliar music and modes of performance (Sanden, 2013; Estibeiro, 2016). Furthermore, combining unpredictable, often chaotic system audio output with the composed features of popular

music allows artists to explore the tension between traditional ideas of beauty and ugliness in the pursuit of the sublime (LeBlanc, 2005; Demers, 2010).

Because reconciling unpredictable system processes with the composed features of popular songs is challenging (Marchini et al, 2017), the use of interactive systems in popular music tends to be limited to more open forms such as blues, jazz and electronica (Bown et al, 2015). However, the inherent indeterminacy of popular songs suggests a natural compatibility. Meaning in popular music is co-created: the audiences understand the lyrics though the lens of their own experience (Hennion, 1990; Smalley, 1996; Jeongwon and Song, 2002) and interpret musical gestures through active, often physical, participation with melody and rhythm (Wicke, 1990; Neill, 2002; Ramsay, 2014). Although these listening modes contrast with the intellectual listening required for the appreciation of Western art music, Smalley's (1996) suggestion that listeners can have a deeper engagement through active exploration of sounds and structures may also be applicable to popular music. While the crossover between the popular and the experimental[1] is nothing new (Sherburne, 2004; Stockhausen et al, 2004; Hansen, 2005; Demers, 2010), there is a continued need to create music that demonstrates *cerebral sensuality* in its requirements for both participatory and intellectual modes of listening (Eno, 1976; Roebroeks, 2008; Ramsay, 2014; Waite, 2014). The use of interactive systems for songwriting and performance suggests rich avenues for such an exploration.

1.1.4. Liveness

The importance of the audience perspective when designing performances involving unfamiliar digital instruments has been widely recognised (Reeves et al, 2005; Biles, 2013), particularly when the self-referential nature of listening is taken into account (Landy, 1994;

[1] 'Experimental' is used here in the broad sense to include avant-garde Western art music (Saunders, 2017).

Smalley, 1996; Biles, 2007; Demers, 2010). While it has been argued that performances involving electronic music represent a new paradigm where traditional performance values are no longer relevant (López, 2004; Bown et al, 2014a), there is a growing consensus that audiences are motivated to understand how the electronic elements are being created (Emmerson, 2007; Demers, 2010; Toplap.org, 2010; Weisling et al, 2018). Correia et al (2017) argue that this understanding directly impacts on their engagement with the performance. Although pre-concert demonstrations and programme notes may help engage audiences through informing them about the technology used, engagement is stronger if this understanding is facilitated by the performance itself (Demers, 2010; Biles, 2013; Bin et al, 2016).

The use of electronic instruments and mediatised material alongside traditional performance practices has led to the abandonment of the binary distinction of 'live' and 'not live' in favour of a continuum: *liveness* (Auslander, 2000; Sanden, 2013). Fels et al (2002) suggest the term *transparency* for the quality of mapping between performer input and the audio output of a digital instrument or system. Higher levels of transparency facilitate both performer expressivity and audience understanding. Croft (2007) distinguishes between *procedural liveness* and *aesthetic liveness*. Procedural liveness occurs when it is simply the case that sound is being created in real-time. Aesthetic liveness exists when procedural liveness is present and there is a perception that aesthetically meaningful actions are mapped to aesthetically meaningful outputs. Sanden (2013) proposes several aspects of liveness:

- *Spatio-temporal liveness:* music is live at a particular time and in a particular place. Both human and machine performers may have their own presence and identity in live performance (Emmerson, 2007).
- *Liveness of fidelity:* music is perceived as being *"faithful to its initial utterance"* (Sanden, 2013, p.11). This also relates to the focus on the here and now through the pursuit of aura - as opposed to seeking to create an idealised version of reality through the pursuit of spectacle (Cascone, 2002a). Sanden (2013) also includes virtuosity and authenticity in this concept.

- *Liveness of spontaneity*: the potential for the unexpected to happen through risk-taking, real-time decision-making and improvisation (Sanden, 2013).
- *Corporeal liveness*: the ability to causally link sounds to the behaviour of an agent (Sanden, 2013). This relates to the notions of *source bonding* (Smalley, 1997) and *embodied understanding* (Wishart, 1994; Demers, 2010).
- *Interactive liveness*: the extent to which music arises from interactions between performing agents (Sanden, 2013). This process of negotiation can facilitate high levels of drama and expressivity (Zappi et al, 2011).
- *Virtual liveness*: the perception of something being performed or someone performing when this is not actually the case (Sanden, 2013). Examples include the synchronisation of fixed media to imply causal relationships (Ramsay, 2014) or the use of a vocoder to imply the presence of a cyborg (Prior, 2009).

Sanden (2013) proposes that these aspects interact as a dynamic network to create overall perceptions of liveness. He also acknowledges that other aspects of liveness may exist and that different networks of liveness may be applicable to different situations. In this enquiry, liveness was considered as a network of liveness (Sanden, 2013) with the following four aspects:

- *Spatio-temporal liveness* refers to the presence of both the human and system as separate, active agents in space and time.
- *Corporeal liveness* refers to causal connections between sounds and the bodies of the human performer and/or visible system elements.
- *Interactive liveness* refers to the extent to which the human performer and system influence one another during performance. Because this relates to the potential for spontaneity, expressivity and uniqueness; liveness of spontaneity and liveness of fidelity are also included.
- *Aesthetic liveness* will refer to the creation of meaning in performance and will therefore include Sanden's (2013) concept of virtual liveness as well as Croft's (2007) concept. Links between the composition, human elements and system elements created through memetic agency will be of particular importance.

1.1.5. Previous work

Figure 3: Equipment set-up for the 21st Century One-Man Band *master's project showing the extensive range of hardware controllers and peripherals. Photo is author's own.*

Before presenting the aims and goals of this research, further context can be provided by a discussion of the master's project that immediately preceded it. The project explored how an album of singer-songwriter material could be performed live (Waite, 2011; National Trevor, 2011). An interactive system was created that enabled a solo performer to create and control accompaniment to their guitar and vocal performance. Considerable variety in terms of how each piece was performed was achieved through an array of hardware controllers including keyboards, footswitches and accelerometers. The use of live looping and granular synthesis in some pieces allowed accompaniment to be created at the time of performance and established a link between the human instrumental/vocal output and machine output. Visuals were developed that created a presence for the system and encouraged audience understanding through the presentation of real-time controller data and audio output visualisation.

Although these performances demonstrated various aspects of liveness, they generally suffered from being an attempt to recreate the original recording. The challenges of simultaneously singing, playing guitar and operating controllers meant that the live versions generally fell short of the ideal of the recorded versions, while the extensive use of pre-sequenced material transferred from the recorded versions restricted the real-time interaction between instrumental/vocal and system audio output. The large amount of controller hardware (Figure 3) meant that the system was awkward to transport and set up, as well as being demanding to operate in performance. Finally, the visual projection of system inputs and outputs provided only minimal clues to the audience in terms of the system processes and no aesthetic connection to the audio material. This PhD enquiry therefore sought ways to respond to these shortcomings by:

- Making each performance of a piece a unique event rather than an attempt to replicate a recording.
- Exploring alternative ways to interact with a system without the need for a large amount of controller hardware.
- Creating visuals that both revealed system processes and the songs' themes.

1.2. Research aims and artistic goals

1.2.1. Research aim

This thesis and the accompanying portfolio of compositions and systems examine the impact of using interactive systems on the songwriting process and the impact on liveness in performance. A variety of systems were created to support songwriting and performance at the intersection of popular and experimental music and demonstrate varying levels of the different aspects of liveness.

1.2.2. Research questions

Two research questions guided the enquiry. The first concerns the impact of creating and using interactive systems on the songwriting process and will be explored in Chapter 4. The second question covers the impact of using interactive systems on liveness and will be explored in Chapter 5. Conclusions will be drawn in Chapter 6.

1.2.2.1. How does the use of interactive systems impact on the songwriting process?

In creating material at the intersection of popular and experimental music, the pieces in the portfolio aimed to achieve *cerebral sensuality*, where the material can be appreciated through both participatory and intellectual modes of listening (Neill, 2002; Roebroeks, 2008; Ramsay, 2014; Waite, 2014). To this end, interactive systems were used to facilitate the exploration of the areas between order and chaos; simplicity and ambiguity/complexity; predictability and indeterminacy; familiarity and the unexpected. The exploration of these dimensions in pursuit of the sublime (Demers, 2010) should naturally subvert songwriting conventions (White, 2005), resulting in the inclusion of the following features:

- Simultaneous acceptance and rejection of stylistic conventions in terms of form and instrumentation (Moore and Ibrahim, 2005).
- Use of chaos, algorithms and process techniques (Hansen, 2005).
- Melodic, harmonic and rhythmic complexity (Lansky, 2005; White, 2005).
- Use of noise and found sound (White, 2005).
- Use of processing to substantially alter the voice and traditional instruments (Hansen, 2005; Demers, 2010).
- Use of destructive techniques such as interruption (Moore and Ibrahim, 2005).
- Use of electronic technology as a compositional tool (White, 2005).
- Complex/abstract lyrical themes (White, 2005).
- Use of textural and atmospheric layers (Moore and Ibrahim, 2005).
- Use of extreme loud-soft dynamics (Moore and Ibrahim, 2005).

- Rhythmic subtlety and timbral variation in the machine elements (Winkler, 2001).

While the above features give an indication of the expected results, the response to this question will focus on the following aspects of the songwriting process:

- The extent to which creating the interactive system can be seen as composition.
- The impact of using interactive systems on the overall songwriting process.
- The effect of implementing interactive systems at different stages of the process.
- Strategies for maintaining coherence when combining the unpredictable audio outputs of interactive systems with the composed features of popular music.
- Strategies for ensuring cohesiveness between the electronic system audio output and human vocal/instrumental output.

1.2.2.2. How does the use of interactive systems in songwriting impact on liveness?

While the importance of the production process in contemporary popular music has led to the idea that writing songs can be conceived of as writing records (Wicke, 1990), the portfolio aimed to reflect an emphasis on live performance. The increased demands on audience attention from the use of a visual channel and the potential for high noise floors at popular music venues mean that the pieces will not be as sonically dense or contain as much arrangement detail as versions for repeated listening in ideal conditions. Rather than attempting to create, recreate or authenticate an idealised recording (Kirn, 2012; Sanden, 2013), the aim here is to make each performance is a unique event.

The response to this question will address:

- How performances with interactive systems demonstrate spatio-temporal liveness by presenting human performers and interactive systems as separate, active agents at the time and place of performance.

- How performances with interactive systems demonstrate corporeal liveness by revealing visual causes for system audio outputs.
- How performances with interactive systems demonstrate interactive liveness through revealing the mutual performative agency of the human performer and the system.
- How performances with interactive systems demonstrate aesthetic liveness through connections between the systems' audio-visual outputs and the themes of the songs.

1.3. Method

1.3.1. Practice-based research methodology

This project is an example of practice-based research. While grounded in ideas from existing theory and practice, the creation of a portfolio of pieces and associated interactive systems was central to the research process (Candy and Edmonds, 2018), with insights derived through reflections on working with the systems in actual composition and performance settings (Nelson, 2013). Links between research and practice were established and maintained through iterative stages of system-building/composing, reflection and literature review (Johnston, 2014; Gurevich, 2014; Waite, 2016). This resulted in the gradual emergence of the four approaches to system design detailed in Chapter 3, rather than establishing the structure of the portfolio at the start.

Similar to research by Eigenfeldt (2008), the systems created through this enquiry were not designed to be musicological tools that codify or recreate works in a particular genre. The goals here include the creation of original music that demonstrates significant stylistic variation and an exploration of the process of doing so. The processes of living composers working in the full range of contemporary styles are of growing interest to the broader

research community (Harper-Scott, 2016), and the value of artist commentaries that clarify their processes and intentions is increasingly recognised (Candy, 2014).

Audience studies have not been carried out in this research. As well as disrupting the creative process (Roels, 2014; Barbosa et al, 2015), effectively representing multiple individual experiences of multiple artworks is extremely challenging and may result in limited and unrepresentative perspectives (Smalley, 1996; Bown et al, 2013). Instead, the audience perspective has been considered throughout (Reeves et al, 2005) through the investigation of the performer's own experience of the works (Candy, 2014), enhanced through informal feedback from expert practitioners (Johnston, 2014).

Evaluation of artworks can be both formative (intrinsic to the creative process) and summative (Candy 2014). Formative evaluation included the laboratory testing of devices and systems to ensure their successful functioning and recording of works in progress to facilitate reflection. In terms of summative judgements, the nature of the conclusions for the two research questions differ. The first question was answered through conclusions drawn from the *examination* of the impact on creative practice, while the second was answered through *evaluation* of the degrees of liveness (Johnston, 2014). In the absence of any absolute scale, comparative measures can be useful in ascertaining overall success (Bown et al, 2014b). Therefore, liveness judgements were made by drawing comparisons between the pieces in the portfolio.

1.3.2. Technical and theoretical constraints

1.3.2.1. Software development tools

The interactive systems in the portfolio were developed using Max (Cycling '74, 2015), Max for Live (Ableton, 2015) and Processing (Reas and Fry, 2015). While Max enables artists to develop ideas from scratch, the ability to embed Max for Live Devices within Ableton Live's environment facilitates a neater, more modular workflow with the advantage of quick and

easy access to signal routing, editing and transport functions, as well as a range of effects and software instruments. Using Processing for system visuals can offer efficiency savings in terms of both workflow and computational load, and can be linked to Max/Max for Live using Open Sound Control (OSC) (Wright, 2005). System components developed with these tools included:

- Input: tools for gathering performance data from the human performer (e.g. signal analysis) and the system (e.g. current bar/beat position).
- Processing: tools for generating parameters and triggers from performance data such as score-followers.
- Response: tools for generating novel audio output through intermodulation, stochastic processes, physical models and input transformation.
- Outputs: tools for the sonification and visualisation of the results of the response algorithms such as loopers, granular synthesisers and visual effects.

1.3.2.2. System hardware

In order to make the system transportable and easy to set up, minimal hardware was used (Richards, 2006). Continuing computing hardware and software developments mean that a single laptop and a small audio interface can handle system inputs, processing and audio-visual response in real-time. The availability and low computational cost of high quality software emulators[2] makes the inclusion of a guitar amplifier an optional inconvenience.

In situations where the human performer was playing guitar, signal analysis and score following methods were used in order to allow the performer to concentrate on their playing, rather than having to set up and operate additional controllers or modify the guitar. This indirect method of control meant that in these situations, the human performer was

[2] Softube guitar amplifier simulation plug-ins running on Universal Audio hardware.

playing *with* the system. Where the human performer manipulated the system directly (i.e. playing *on* the system), simple, portable yet highly flexible controllers were used. These were the Korg *Nanokontrol* (Korg, 2018), the Novation *Launchpad* (Novation, n.d.) and the computer keyboard. Non-tactile and touchscreen controllers were avoided due to the lack of haptic feedback.

Finally, in the interests of making performances adaptable to a wide range of venues, the audio output was limited to two channel stereo and the visuals to a single projector.

1.3.2.3. Audio and visual outputs

All of the systems in the portfolio responded to human performer input with real-time audio and visual output. It is seen as essential by some for interactive systems to include visual outputs (Johnston et al, 2008), and the use of the visual channel may have a significant, positive impact on liveness (Zappi et al, 2011; Sanden, 2013; Bown et al, 2014a; Mainsbridge & Beilharz, 2014).

1.3.2.4. System design

The use of indeterminate processes with significant performative agency over the composition should result in each performance becoming a unique event, with no single idealised version of the work. However, because the systems were not designed for purely improvisational situations, sufficient elements of the compositions would need to be retained in order for them to be clearly identified as the same piece over repeated performances. Systems therefore needed to contain both score-driven and performance-driven characteristics (Rowe, 1993).

The systems were designed so that they did not require large amounts of practice. The central idea is that the systems behave as a junior partner in composition and performance (Chadabe, 1984) and so the amount of rehearsal should be equivalent to devising and

rehearsing with another human performer. Facilitated by the constraint of using minimal additional hardware, this led to the focus on the use of familiar technologies to interact with the systems.

2. Background

2.1. Interactive systems and the songwriting process

2.1.1. System building as composition

In 1.1.3, it was suggested that composers collaborate with tools and technologies rather than have mastery over them (Prior, 2009). Therefore, if a composer creates their own tools then this can be seen as part of the composition process (Chadabe, 1984; Richards, 2008; Brown and Sorensen, 2009). Furthermore, the iterative activities of building a system and then exploring its creative potential can result in *emergence*, where new structures arise from the interaction of system components (Faubel, 2013; Gurevich, 2014).

Maeda (2004) highlights the potential for artists to use software to explore ranges of behaviour in their work as well as fixed events. This creates the possibility of working with real-time processes where the precise outcome is unknown (Ribas, 2014). Instead of meticulously crafting a static object, the composer creates fields of possibilities and networks of behaviours. Composing in this way has been contrasted with traditional composition through the metaphor of trying to engineer a seed rather than build a tree (Toop, 2004), while the experience of working with unpredictable systems in performance has been likened to sailing a boat (Chadabe, 1984). The presence of well-documented software environments (e.g. Max and Processing) and connection protocols (e.g. Max for Live and OSC) aimed at artists mean that the creation of interactive music systems to explore these composition techniques is manageable for composers with little previous computer programming experience.

While indeterminate techniques may be used to generate material that can be fixed by the composer through recording and curation (Estibeiro, 2016), they can also remain as live processes that produce unique results with each performance (Cage, 2004). Furthermore,

the behaviour of a system may be designed to increase in complexity as a piece progresses (Demers, 2010), leading to a continuous learning, negotiation and decision-making by the human and machine performers. For example, Gordon Mumma's (1967 [2002]) *Hornpipe* begins as a solo before requiring the performer to respond to both the system's electronics and the acoustic properties of the performance space (Dewar, 2009). As well as *composing behaviours* (Di Scipio, 2003), *designing interactions* becomes an integral part of the composition process (Johnston, 2013). Possible ways to implement changes in behaviours and interactions during the course of a piece include the use of goal-orientated systems that adjust their mappings autonomously (Chadabe, 2002) and score-following mechanisms that activate predetermined changes (Waite, 2016).

While the ability of an interactive system to be used across multiple pieces may be seen as an advantage (Rowe, 1993), its creative possibilities may become quickly exhausted when applied across multiple works (Smalley, 1996). Winkler (2001) suggests that the creation of the response and output components of the system may well be bespoke for each piece and can therefore be seen as a key part of the composition process; whereas the more functional input and processing components are likely to be reused. Therefore, composers creating their own interactive systems do not need to devote long hours to creating user intuitive interfaces for imagined future users (Brown and Sorensen, 2009) and can focus instead on the musical aspects of the system.

2.1.2. Overview of the songwriting process

Examinations of the composition process for electroacoustic music suggest two stages: the generation of material and the organisation of this material in time (Emmerson, 2007; Estibeiro, 2016). When working with interactive systems, Chadabe (1984) suggests a two-stage model: first building the system and then playing with it. Discussions of the songwriting process in popular music suggest a three stage process: the creation of the initial song;

creating the arrangement before fixing the work through the recording and performance (Hennion, 1990; DeSantis, 2015; *The First Time*, 2016; NPR Music, 2016).

Although methods vary across time and composer (Lansky, 2005), there is some consensus on at least the initial stages of the process by which material is generated, tested and stored or rejected (Emmerson, 1986; Estibeiro, 2016). Initial inspiration may come from a variety of sources including exploration of musical ideas through improvisation and play (Wishart, 1994; Reich, 2002; Hansen, 2005; Eigenfeldt, 2008); manipulation of existing sound recording (Demers, 2010) or non-musical concepts and actions (Jeongwon and Song, 2002; Lansky, 2005). In songwriting, the generation stage is equivalent to the creation of the main melodies, lyrics and basic instrumental parts of the song. This is followed by the arrangement stage, which may involve more collaborative working (Hainge, 2005; MacDonald, 2008; NPR Music 2016) as the song's arrangement is key in determining artistic success (Hennion, 1990). Band members and producers therefore aim to ensure that the various musical elements complement one another and enhance the existing song (Jones, 2005; NPR Music, 2016). Though the organisation of existing material might be the principle activity at this stage, there may also be generation of accompaniment layers as well as the refining of existing material (Hennion, 1990).

Although the audience perspective is often considered at the arrangement stage (Hennion, 1990), recording and performance affords songwriters further objectivity. While producers make significant artistic contributions at the recording stage through processing and editing (Wicke, 1990; Eastwood, 2014), more radical outcomes may result. For example, elements of U2's *Lady with the Spinning Head* (U2, 1992) from early *Achtung Baby* sessions eventually became three separate album tracks (U2, 1991; Greene, 2014); while the structure and instrumentation of Radiohead's (1997) *Paranoid Android* was significantly altered following live performances before its appearance on *OK Computer* (*The First Time*, 2016).

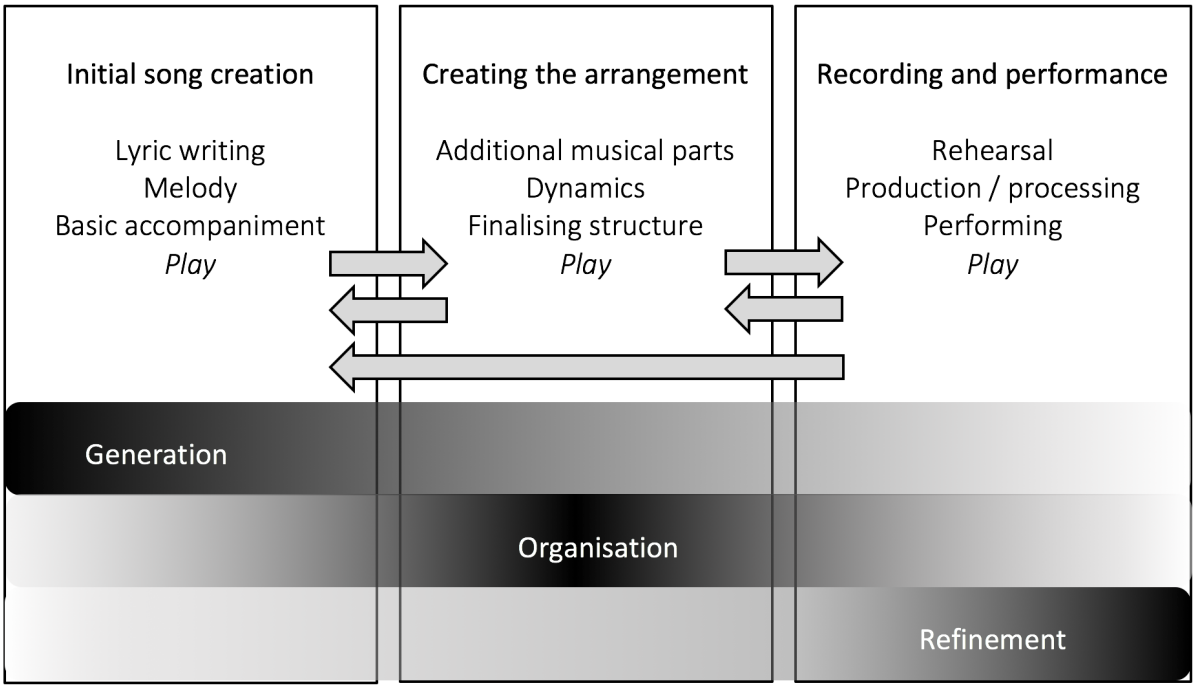

Figure 4: Visualisation of key stages and activities in the songwriting process.

Figure 4 illustrates the three stages of the songwriting process and lists the key activities that define each stage. These stages may well be iterative, with the activities of generation, organisation and refining occurring at each of these, albeit to different extents. Play, through improvisation and exploration is present throughout the process (Wishart, 1994; Prior, 2009; Ramsay, 2014).

2.1.3. Implementing interactive systems at different stages of the process

Interactive systems may be used throughout the composition process or be implemented at specific points within it. For example, a system may be used at the start of the process to assist with initial generation of material which then becomes fixed through linear techniques or at later stages to create indeterminate accompaniment layers to fixed material.

Real-time electronic processes can be used in the initial stages of songwriting to assist with idea generation. Eigenfeldt (2008) distinguishes between timbre-based, signal processing

approaches and representational (e.g. MIDI-based) approaches. Examples of the former include the use of vocal effects by Bono of U2 and Thom Yorke of Radiohead in the early stages of songwriting to create new personas and influence lyric-writing (Reynolds, 2001; Hilburn, 2004). Representational reflexive systems such as *Continuator* (Pachet, 2006), *Voyager* (Lewis, 1999) and *GenJam* (Biles, 2013) can be used to generate musical material through improvisation. Eigenfeldt (2008) argues that a composition invariably starts with improvisation to create an interesting musical idea, and that codifying such an idea in a system is extremely difficult compared to the relative ease of translating well-defined rules for extending this idea into arrangements. He therefore concludes that using computers as compositional partners is better suited to the latter stages of composition, such as the generation of accompaniment through generative methods (as in *Kinetic Engine* (Eigenfeldt, 2009) and *Jambot* (Gifford, 2011)), or through transformative methods (as in augmented instruments such as Ben Neill's *Mutantrumpet* (Bill Jones, 2009)).

Systems for the performance of popular song such as the *Reflexive Looper* (Marchini et al, 2017) allow for the recreation of composed features without relying on the playback of pre-sequenced media. However, the system's output must be programmed with the piece's score to ensure that its response is appropriate. This trade-off between interactivity and ability to accompany a fixed score is well established as a classification dimension for interactive systems (Rowe, 1993).

2.1.4. Combining interactive system output with popular music features

Systems with high levels of interactivity tend to be limited to improvisational situations and are less compatible with the fixed structures of composed popular music (Bown et al, 2015; Marchini et al, 2017). Interactivity in systems used for popular music therefore tends to be compromised by a reliance on pre-sequenced material to supply the rhythmic and/or harmonic backing for improvising lead instruments (Biles, 2013); a strict adherence to a pre-

determined score by both human performer and system (Marchini et al, 2017) or by being limited to a minor, accompanying role (Gifford, 2011).

In the context of live electroacoustic music involving acoustic instruments, Estibeiro (2016) suggests that the application of a system's compositional algorithms to the instrumental parts can create commonality. Commonality might also be created more organically through improvisation with an interactive system at the very early stages of composition to maximise the two-way influence between human and system output (Waite, 2016). As the piece progresses towards performance, both the instrumental and system output becomes increasingly fixed by the composer, who uses their musical sensibilities to ensure rhythmic and harmonic coherence (Eno, 1976; Reich, 2002). These constraints may become a feature of the system or be applied dynamically through representational data derived from the live input or score-following (Cont, 2008; Waite, 2016; Marchini et al, 2017). Alternative strategies may include the use of a clear harmonic or rhythmic context to exert a pull on the abstract material (Demers, 2010), or to extend the piece with a section that is partially freed from harmonic and/or rhythmic constraints to allow space for indeterminate output to be foregrounded.

The temporal relationships between human and system output are also important here as they will impact on the foregrounding/backgrounding of the system audio outputs. Pachet (2006) details possible interaction protocols, which are illustrated in Figure 5. *Turn-taking* interactions are implemented in reflexive, improvisatory systems in which human and machine agents trade solos; *accompaniment* interactions would suit augmented instruments whilst *collaborative* would suit the real-time generation of continuous layers. Collaborative interactions would therefore be highly relevant to popular music where several layers of instrumentation are required, such as drums, bass and backing vocals.

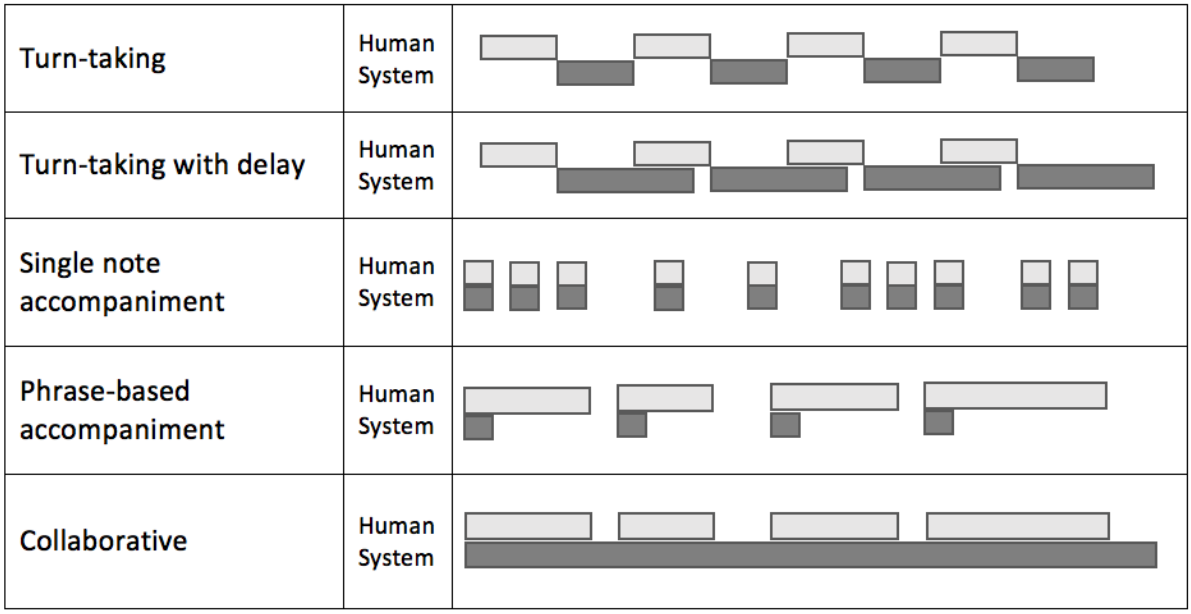

Figure 5: Time-based interaction protocols in interactive music systems (adapted from Pachet, 2006).

2.1.5. Combining electronic system output with human instrumental/vocal sounds

The revolutionary approaches of early twentieth-century artistic movements pitted technology directly against tradition in the pursuit of a radically new music (Chadabe, 1997; Cage, 2004; Reynolds, 2004; Sanden, 2013). Whilst tensions still exist in terms of the encroachment of electronic techniques on human elements in composition (*The Art of the Loop*, 2014), production (O'Connor, 2015) and performance (Willgoose, 2013), sounds from both instrumental/vocal and electronic realms are regularly combined to extend and enhance the repertoire of traditional instruments rather than replace them (Varèse and Wen-chung 1966).

While it might be argued that any sound emanating from a loudspeaker becomes electronic and disembodied through removal from its acoustic source, characteristics pertaining to familiarity and physicality persist (Mooney, 2005; Emmerson, 2007). Auslander (2000) warns that combining material from traditional instrumental/vocal and mediatised elements in live

performance may lead to the *con-fusion* of realms rather than successful fusion. The use of pre-sequenced material or electronic instruments to replace human performers and/or acoustic instruments generally results in inferior versions of reality that only serve to highlight that something is missing (Croft, 2007; Demers, 2010). Therefore, some authors argue that the innate characteristics of the machine elements should be explored to their full potential (Cascone, 2002b; Bown et al, 2009; White, 2010).

Estibeiro (2016) warns that the co-presentation of clearly separate acoustic and electronic layers compromises the reception of the piece as a coherent perceptual whole. Strategies are therefore required that connect the two realms without compromising their innate qualities. These include creating perceptual continua between the instrumental/acoustic and electronic layers (Estibeiro, 2016); creating behavioural links (Pachet, 2006); the use of deterritorialisation and re-embodiment techniques (Hansen, 2005) and unification through extra-musical themes (Smalley, 1996).

Perceptual continua techniques include the use of granular synthesis and other electronic processing techniques to create a dynamic link between the instrumental and electronic layers (Estibeiro, 2016). Destructive processing techniques (such as filtering, enveloping and sample trimming) in particular serve to remove meaning and therefore increase commonality with the more abstract realm of electronic sounds (Demers, 2010). Behavioural links can be established by the manipulation of system output using representational data to control pitch and rhythm (Pachet, 2006). In popular music, deterritorialisation techniques can remove the voice and guitar from their privileged position at the centre of the perceptual field altogether or bring them into the electronic realm through extensive processing (Hansen, 2005). Electronic sounds can also be brought closer to the realm of the instrumental through re-embodiment, for example through the use of gestural controllers in live performance (Dezeen, 2016). In acousmatic situations, the use of 'indicative' sounds (Smalley, 1996) with 'living presence' (Emmerson, 2007) can create in the mind of the listener an imagined cause (Wishart, 1994) through the presence of a clear reference to the real world. Smalley (1996) also suggests that the use of extra-musical references can generate a sense of unity to the composition as a whole. Examples of this in popular music

include Radiohead's (2001) *Like Spinning Plates* where the lyrics and the synthesiser gestures are linked through onomatopoeia (Jones, 2005). Hennion (1990) argues that these kinds of links can be fundamental to audience reception.

2.2. Interactive systems and liveness

2.2.1. Spatio-temporal liveness

Spatio-temporal liveness refers to the presence of both the human and system as separate, active agents in space and time. Brown (1999) suggests that the function of performance is to bring a work, performers and audience together at the same time - thereby closing the gap between art/reflection and life/being. Greenwood (2014) contrasts recordings and performance to highlight the value of musicians and audiences sharing an intimate space to create and witness a unique event at a specific point in time. These observations suggest the importance of both the human performer and the interactive system having a perceivable presence in space and time.

The performances of the pieces in this portfolio aim to present the human performer and interactive system as independent entities, working in partnership and linked by a common sonic environment (Eldridge, 2013). In the staging of live music involving human performers and electronics, the human performers have often been prioritised over machines, which, despite being a significant element, are frequently positioned off stage or away from its centre (Zappi et al, 2011).

When working with computer-based machine performers, there may be a need to equip them with some kind of body in order for multisensory experience, satisfying interaction and the creation of meaning to take place (Emmerson, 2012a). While a human performer might

be able to interact with the system through tactile controllers, from the audience perspective the use of the visual channel would be a more practical solution. Although there is evidence to support that audiences can infer the presence of machine agents in the absence of visual information (Bown et al, 2014a), perceiving a performing body is often equated with seeing it (Sanden, 2013). The visuals approach would also be more applicable to live popular music settings and for video recordings of performances. However, visuals must be carefully designed and staged to prevent detracting from the presence of a human performer in the pursuit of spectacle (Cascone, 2002a; Jordà, 2005; Tate, 2005; Auslander, 2008; Sanden, 2013).

Although it may be the case that an interactive system is an active agent in performance, this may not be obvious to an audience. Biles (2013) reports that in performances with *GenJam*, audiences thought he was performing to a fixed backing track rather than improvising with a live system, even when they were told that this was the case. Even when systems have a visual element representing the machine functioning, the extensive use of video and backing tracks in popular music may lead an audience to presume that the performer is simply synchronising their performance to fixed audio and video playback. Design strategies are therefore needed to demonstrate that the system is active as well as present, resulting in a sense of 'aliveness'.

Robin Rimbaud discusses how the LED sculpture *Origin* demonstrates this 'aliveness' through the use of light to present itself in a state of readiness between performances (Creators, 2011). Recent performances by Nosaj Thing and Daito Manabe demonstrate the active nature of the visuals system through the use of live video of the human performers in the system visuals (lute, 2017). The practice of live coding demonstrates that while audiences may not understand the exact relationship between projected code and the sonic results, it is clear that the code is playing an active role in performance (Toplap.org, 2010; TEDx Talks, 2013). A similar conclusion can be drawn from Jon Hopkins' movements in performance: while the exact relationship between his actions and the system's results may be difficult to ascertain, they support the perception that the system is live and not a backing track (KEXP, 2014).

2.2.2. Corporeal liveness

Corporeal liveness refers to causal connections between sounds and the body of the human performer and/or visible system elements. Though there may be exceptions (López, 2004; Bown et al, 2014a), it is widely agreed that audiences are generally motivated to seek out the causes of the sounds they hear (Emmerson, 2007; Demers, 2010; Berthault et al, 2014; Estibeiro, 2016). Sound-producing physical gestures provide links between the physical world and mental experience (Visi et al, 2014), which may be particularly important to meaning creation in the reception of electronic music (Wishart, 1994; Smalley, 1996; Emmerson, 2007). The perceived physicality of a musical performance may also directly contribute to an audience's emotional response (Creators, 2011).

In performances involving acoustic instruments, perceptual assessments by experts and non-experts show little difference, suggesting a common embodied understanding (Gurevich and Fyans, 2011). Though embodied understanding is particularly important in popular music due to the importance of participatory listening (Wicke, 1990; Neill, 2002), electronic music frequently uses sounds that are disembodied through the absence or removal of physical causes (Ramsay, 2014). Gestural approaches to electronic music performance therefore aim to restore physical causes of sound through re-embodiment to allow audiences to better relate to the performance (Moldover Musical-AntiHero, 2007; Emmerson, 2007; Sanden 2013). This is particularly important for triggering events rather than controlling an existing sound: 'striking' gestures for triggering sounds are associated with a higher degree of corporeal liveness than 'tweaking' gestures such as adjusting a rotary fader (Sanden, 2013; Bown et al, 2014a). Furthermore, bodily gestures that give cues for what is about to happen (Ramsay, 2014) and gestures that demonstrate a response to a musical event (Creators, 2011) can also be important in establishing causal relationships.

The link between perceiving sounding entities and seeing them (Sanden, 2013) suggests a strong role for visuals in demonstrating the causes of sounds as well as the presence of the system. Ribas (2014) provides a taxonomy of real-time audio-visual approaches:

- *Audio-visual entities*: where distinct visual elements represent distinct sounds (Figure 6).
- *Interactive sounding shapes*: where visual elements respond to the overall sonic landscape (Figure 7).
- *Sounding figurations*: in which the performer creates sound by drawing shapes into the visuals (Figure 8).
- *Audio-visual reactions to interactions*: in which the visual parameters respond to gestural performance data via non-linear mappings (Figure 9).

Figure 6: Ben Bengler's (2011) performance of Schwanensee Splitter *features scrolling visualisations of sonic events. Used with permission.*

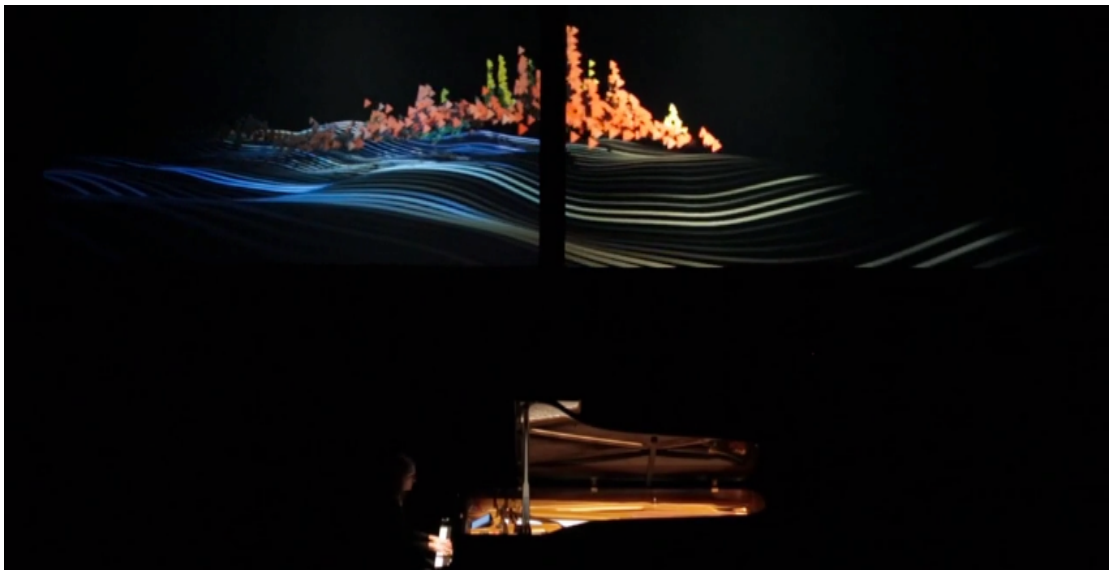

Figure 7: Performance of Ravel Landscapes *featuring visuals by Davide Quayola based on signal analysis techniques (Stark, 2014). Source: www.quayola.com. Used with permission.*

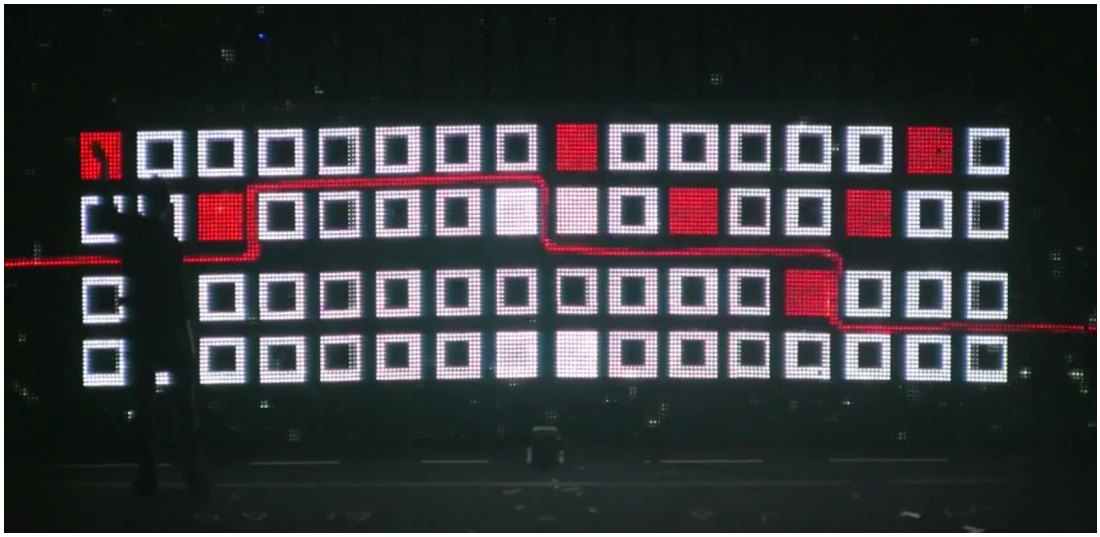

Figure 8: Performance of Nine Inch Nails' Echoplex *featuring a giant, touch-activated sequencer at the back of the stage. Photo from a still of a video by chaonotic (2009). Used with permission.*

Figure 9: Figure 55: Ben Neill's performances make use of abstract visuals that respond to his Mutantrumpet*. Photo by Peter Gannushkin. Source: www.benneil.com. Used with permission.*

Correia et al (2017) report that overall, the *audio-visual entities* and *sounding figurations* approaches are the most useful for promoting audience understanding, although they warn that in the latter, over-simplistic mappings may result in a live performance becoming a technical demonstration. While therefore less suitable for demonstrating corporeal liveness, *interactive sounding shapes* and *audio-visual reactions to interactions* may be useful for demonstrating that a system is active (spatio-temporal liveness); providing cues for meaning creation and overall stylisation (aesthetic liveness).

In attempting to demonstrate causality, a distinction needs to be drawn in terms of presenting visual representations of the audio output from system processes rather than the processes themselves (McCormack, 2013). Systems based on physical models facilitate the visual representation of processes (Fels et al, 2002; Johnston, 2013; Graham and Bridges 2014) whereas abstract algorithms (such as stochastic processes) may be difficult to translate into a visual equivalent (Toplap.org, 2010).

2.2.3. Interactive liveness

Ribas (2014) discusses how the process of interaction between performing agents (the aesthetics of production) may be of significant interest to audiences as well as the outcome of interactions (the aesthetics of reception). Furthermore, distributing the ability to influence the performance between agents is an important source of drama (Winkler, 2001). This section will further explore levels of interactivity in interactive systems and how the mutual influence between agents can be made perceivable to the audience.

In the use of interactive systems, there is a great deal of variety in the distribution of performative agency between human and machine performers. At one end of the scale are fixed, human-performed parts strictly synchronised to a fixed electronic accompaniment (Garnett, 2001; Sanden, 2013) which is controlled by a timer, a score-follower or simply by recording (Estibeiro, 2016). At the other extreme, human and machine performers might improvise together in a performance network that allows the system to generate unpredictable responses in real time (Sanden, 2013). Figure 10 demonstrates this variety by ranking examples of interactive systems in terms of their level of interactivity and shows how overall interactivity arises from the indeterminacy of the system and the potential for improvisation by the human performer.

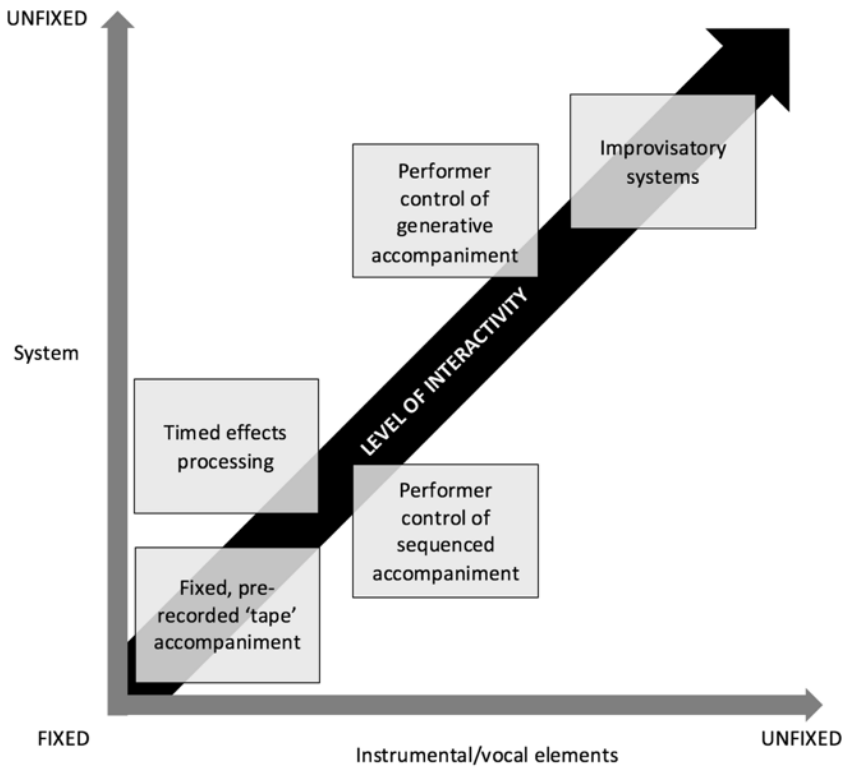

Figure 10: Levels of interactivity in interactive music systems involving instrumental/vocal elements.

As discussed in 3.2.4, combining indeterminate system output with composed elements is difficult (Bown et al, 2015; Marchini et al, 2017) unless the human performer remains the senior partner with ultimate control (Chadabe, 1984; Winkler, 2001; Waite, 2016) and the indeterminacy of the system output is constrained (Marchini et al, 2017). Situations in which the system is afforded equal and significant performative agency tend to be limited to improvisatory performances (Eigenfeldt and Pasquier, 2009).

Extending Pachet's (2006) interaction protocols, Johnston et al (2008; 2009) discuss three modes of real-time interaction that will have a direct bearing on performative agency, which are shown in Figure 11. *Instrumental mode* involves direct control of the system by the player. *Ornamental mode* involves the system autonomously generating a separate accompaniment to the human performer's output, which may influence aspects of the playing/singing of the human performer. *Conversational mode* involves a more balanced distribution of performative agency through a switching of power, leading to higher levels of interactivity. In order to balance the need to demonstrate system interactivity with

performing composed material, interactive systems for popular music might incorporate different modes of interaction between the human performer and the various system elements and foreground these at different points in the song.

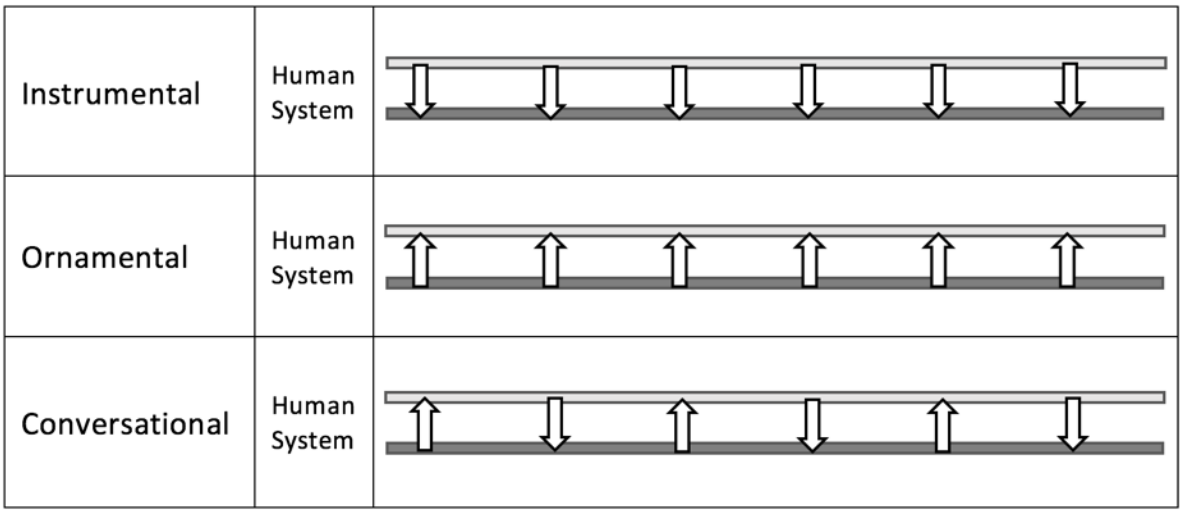

Figure 11: Control-based interaction protocols in interactive music systems (after Johnston et al, 2008; 2009).

Whilst some composers remove processes that are not considered important to the reception of the piece in live performance, these processes may be important for revealing the process of interaction between human and system. For example, Estibeiro (2016) discusses the removal of live recording processes in favour of using pre-recorded sound files. Whilst this approach may indeed be unnoticeable to the audience and result in greater compositional accuracy, the inclusion of the live recording process and making it clear to the audience that it is taking place could contribute to the appreciation of the performance through the aesthetics of production as well as reception (Ribas, 2014). This is supported by Correia et al (2017), whose study of audio-visual practices demonstrates a link between the clarity of the performer's manipulations of the system and audience engagement.

Gurevich and Fyans (2011) conducted a study of digital musical instrument interactions using five questions relating to audience perceptions of interactive liveness. Among the findings were a link between the perceived level of indeterminacy of the performance and the perception that the performer was playing with the instrument's processes rather than trying to control it. It was also discovered that audiences associated indeterminacy with a less

binary view of 'right and wrong' musical output and that error-free performances, while difficult to judge, were indicated by their impression of the performer's confidence.

Winkler (2001) warns that overly simple interactions could quickly become dull for an audience. A potential solution could be the use of dynamic mappings, which could combine clarity at the start of the performance with increasing complexity as the piece progresses. This may also involve shifting power balances between the human performer and the system, which may add to the sense of drama in performance. Therefore, as well as the use of multiple modes of interaction, dynamic mappings could therefore be applied as a design strategy to maintain both engagement and understanding (Gurevich and Fyans, 2011).

Due to the human performer's confidence being a factor in audience reception (Gurevich and Fyans, 2011), it is important to consider interactive liveness from the performer's point of view as well as the audience perspective. From the performer perspective, interactive liveness can be equivalent to the responsiveness and expressiveness of interactive system (Fels et al, 2002). Reich (2002) found performing with his custom-built *Phase Shifting Pulse Gate* by twisting the dials of that the device so unsatisfactory that it was never re-used. Reich's reflections are further supported by Brown (2010), Zappi et al (2011) and Correia et al (2017); who suggest that the performer's engagement, understanding, proficiency and expressivity depends on a positive experience of using it. In addition to effective methods of interaction, this experience may be further enhanced through the minimal use of pre-sequenced material and significant use of indeterminate processes which liberate the performer from attempting to reproduce an ideal score or recording (Cascone, 2002a; Sanden, 2013).

2.2.4. Aesthetic liveness

Aesthetic liveness relates to the creation of meaning in performance, taking place through:

- thematic connections between system processes, system audio/visual outputs, instrumental/vocal elements and lyrics;
- imagined causes for system outputs (virtual liveness) and
- the stylisation of system visual outputs.

'Poietic leakage' is a term applied to the process of informing the audience about the creative and compositional processes involved in making the work (Ramsay, 2014). This may occur through references contained within the work itself, or by external means such as programme notes, talks and demonstrations. Bin et al (2016) found that while pre-concert demonstrations might be useful in increasing audience understanding of unfamiliar instruments, they had little impact on engagement and enjoyment. Biles (2013) suggests that audiences base their understandings on what they experience during the performance rather than what they are told outside of it. Therefore, as mentioned in Chapter 1, the use of references within the performance itself may be a more successful strategy and serve to facilitate understanding and engagement on an artistic as well as a technological level.

The work presented in performance will reveal traces of the memetic agency between the human performer, the system and the broader compositional themes, created through the iterative cycles of traditional songwriting activities and system-building discussed in Chapter 4. These traces may be heard through *living presence* (Emmerson, 2007) and *indicative relationships* (Smalley, 1996) that link the system's sounds to the compositional themes through external references. Visuals provide another channel for these references. Aspects of the visuals that reveal the machine through the presenting of the body of the system (spatio-temporal liveness), provide visual cues for the causes of sounds (corporeal liveness) and reveal interactions with the performer and the score (interactive liveness) can be co-presented with meaningful visual materials that reveal the composition. As suggested in 2.2.2, these materials may use the *interactive sounding shapes* or *audio-visual reactions to interactions* approaches in combination with visual elements enhancing corporeal liveness through the *audio-visual entities* and *sounding configurations* approaches.

In Sanden's (2013) concept of *virtual liveness*, imagined causes of sounds may result from the combination of mediatised system elements with other system or human elements. For example, tightly synchronised sound and music played back as a fixed video may give the impression of a real-time link (Ramsay, 2014); fixed electronic accompaniments to acoustic instruments can be composed to sound interactive (Estibeiro, 2016) and electronically-produced sounds can be perceived as emanating from a human performer (Sanden, 2013). Sanden discusses how the combination of mediatised elements with human performance elements can result in the perception of human-machine hybrids (cyborgs) in the minds of listeners.

Although the use of visuals may result in the human performer being outshone (Auslander, 2008) through the pursuit of spectacle (Cascone, 2002a), Correia et al (2017) found that well-designed, highly stylised visuals were effective in engaging audiences. This suggests that interactive system designers could aim for the *technological sublime* in which machines become aesthetic objects in their own right (Demers, 2010). Furthermore, as an equivalent visual output, the body of the human performer may make non-sounding gestures that can contribute to a rich aesthetic experience through the communication of meaning (Gurevich and Fyans, 2011; Correia et al, 2017).

3. The portfolio

This section discusses the portfolio of systems and compositions developed during the course of the enquiry. Section 3.1 outlines the evolution of the four system approaches. Sections 3.2-3.5 provide detail on each system approach before discussing each composition in depth.

3.1. Portfolio narrative and summary

The narrative of the portfolio development reveals an emergent, iterative methodology where, led by the research aims, research questions and artistic goals, each system approach informed the development of the next. This is evident in the series of departures from and returning to songwriting conventions. The portfolio begins with a radical departure: guitar and many popular song features are abandoned as algorithmic processes are foregrounded in the 'explorative-generative' pieces. The 'multi-tool' approach re-introduces typical popular music features, before a second departure in the pursuit of a more experimental aesthetic and stronger audio-visual relationships ('typing' pieces). Finally, the 'metaphor' approach re-introduces guitar and vocal performance whilst retaining these audio-visual links.

Figure 12 shows the development timeline of the pieces in the portfolio. Where the pieces are out of the sequence described above, initial song creation occurred before the development of the system (*Unquiet* and *Broken Starling*). The pieces which span several years either involved the completion of a recorded version before the creation of a live version (*I Begin Where You End* and *Broken Starling*) or the rejection of initial composition ideas followed by a sustained break in development (*Leave My Room*).

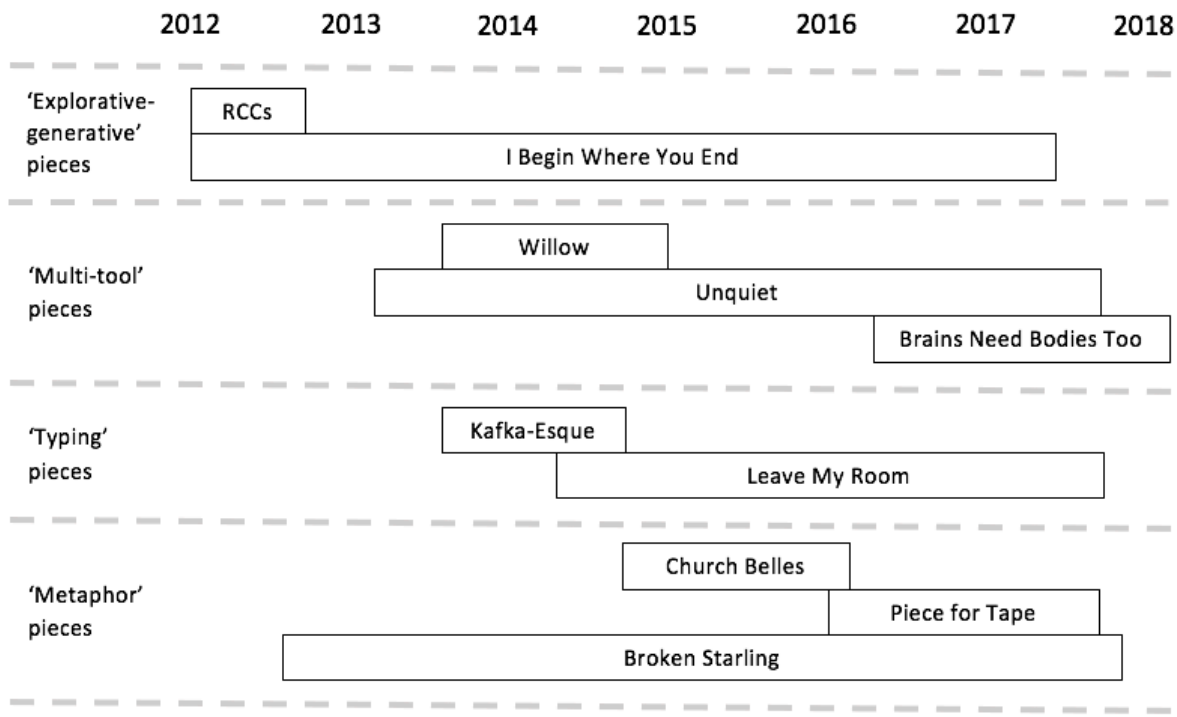

Figure 12: Timeline showing the development of the portfolio. RCCs is Rows, Columns, Collisions*.*

The 'explorative-generative' approach involved the development of a complex sequencer that used a *Launchpad* as its interface. *Rows, Columns, Collisions* (RCCs), arose from open-ended exploration of the tool, resulting in a highly abstract piece. *I Begin Where You End* re-introduced song structures and vocals in an attempt to use this tool in the context of more conventional songwriting practices. The visuals for both pieces represent the *Launchpad* and its functioning in order to reveal the system's behaviour to the audience.

The 'multi-tool' approach was devised as a way to generate accompaniment for conventional guitar and vocal material. These pieces involve the use of multiple tools to create rhythmic, textural, harmonic and melodic accompaniment; controlled by both real-time instrumental/vocal input and a score-follower. These tools include audio loopers, granular synthesisers, rhythm generators and arpeggiators. The visuals represent the behaviour of the system through the display of real-time audio and representational input and output data.

The 'typing' pieces aimed to place lyrics at the centre of the performance by typing rather than singing them, while exploring the potential of a computer keyboard and text-based

processes to generate the music. *Kafka-Esque* is rhythmically ambiguous and uses a pre-existing text fragment, whereas *Leave My Room* features a clear pulse and original lyrics. In both pieces, the visuals include the projection of each letter as it is typed and image manipulations that support the themes and narrative of the lyrics.

The 'metaphor' pieces marked a return to traditional song forms and instrumentation. In contrast to the 'multi-tool' approach, the system for each piece featured a central device based on an audio-visual metaphor drawn from everyday culture and experience. The metaphors used were bells (*Church Belles*), a washing machine (*Broken Starling*) and cassette tapes (*Piece for Tape*). As well as influencing the systems' functioning, the metaphor was connected to the songs' lyrical themes. Stylised representations of the metaphor were presented as the system visuals.

3.2. 'Explorative-generative' pieces

3.2.1. Introduction and background

3.2.1.1. Grid-based systems in live electronic music

Grid-based controllers and software are used extensively in electronic music, with virtuosic performers such as Deadalus (XLR8R, 2016) and Madeon (Madeon, 2011). As well as the *Launchpad*, popular grid-based controllers include the *Monome* (Monome, n.d.) and Ableton's *Push* (Kirn, 2015b). The *Launchpad* was used here due to its customisability through an OSC wrapper (Kirn, 2009) or Max for Live.

There is a multitude of bespoke sequencing applications for these devices, including generative tools. In the Max for Live device *Push Pong* (Towers, 2014), the user activates

pulses that move across a grid horizontally and vertically. These pulses collide with one another and the grid edges, creating a sound event and causing them to reverse direction. The system can be described as generative as its precise behaviour is difficult to predict. Several generative music mobile apps such as *Bloom* (Eno and Chilvers, 2008) also create sound through collisions between dynamic shapes. Bongers (2007) argues that the most successful electronic instruments are those that resemble acoustic instruments in the sense that interface and sound generation mechanisms are technically and conceptually inseparable. While the sound generation mechanisms may be separate, systems for grid controllers and generative audio visual mobile applications exhibit tight coupling between the interface, event generation and visual response. They therefore demonstrate significant potential in being intuitive for performers to use and simple for audiences to understand (Correia et al, 2017).

3.2.1.2. Emergence through intermodulation

The 'explorative-generative' pieces were created using a system that incorporates multiple step sequencers within a single device. Related to the concepts of *intermodulation* (Chadabe, 1997) and *music as a gradual process* (Reich, 2002), each sequencer can run at a unique tempo, with its behaviour modifiable by the others. It was anticipated that, similar to Arne Eigenfeldt's *Kinetic Engine* (Eigenfeldt, 2008) and Bret Battey's *Nodewebba* (Battey, 2014), complex yet coherent behaviours would emerge from these interactions.

3.2.2. System architecture

3.2.2.1. A complex sequencing tool

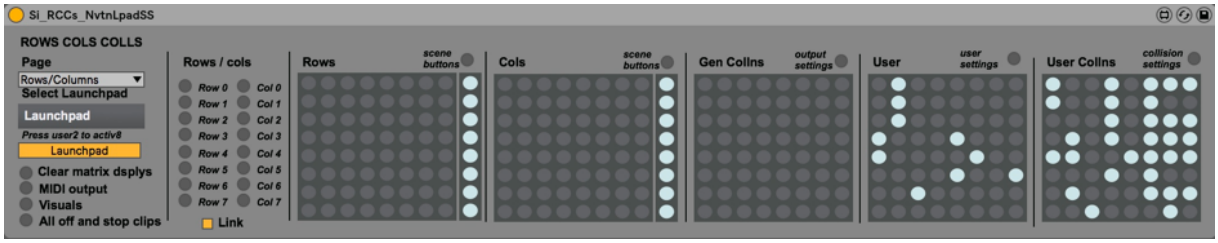

Figure 13: Main Max for Live device used in Rows Columns Collisions *and* I Begin Where You End.

A Max for Live device (Figure 13) was created that enables the *Launchpad* to simultaneously function as an arpeggiator, a step sequencer, a generative sequencer and a digital instrument. Its MIDI outputs were linked to synthesis and sampling modules with mixing and transport functions controlled with a *Nanokontol.* Visuals revealing the behaviour of the sequencer were built in Processing (Figure 15). The architecture of the system is shown in Figure 14, and its capabilities are as follows:[3]

- Metronome pulses for rows and columns are activated by the *scene* pads on the side of the Launchpad. The length, direction, speed and output scaling of each row and column can be set independently. This pulse can itself function as an arpeggiator, or act as a cursor for a step sequencer (red and green squares in Figure 15).
- User-activated pads can generate MIDI notes through collisions with the metronome pulse. The pads can be set to be toggle buttons, like a typical step sequencer, or momentary buttons, i.e. they have to be held by the user to remain activated (yellow squares in Figure 15). Alternatively, these 'user' pads can be played like a keyboard instrument.
- Collisions between row and column pulses generate MIDI notes (white squares in Figure 15).

[3] Video demonstration at: https://www.youtube.com/playlist?list=PLEf_T--_c4UrYpNPnoD2vxGE_yesMQSHo

- Each row and column pulse can modulate the behaviour of another through the use of bespoke Max for Live devices.
- The activation of rows and corresponding columns can be linked through a toggle control on the Max for Live interface ('Link' button shown in Figure 13).

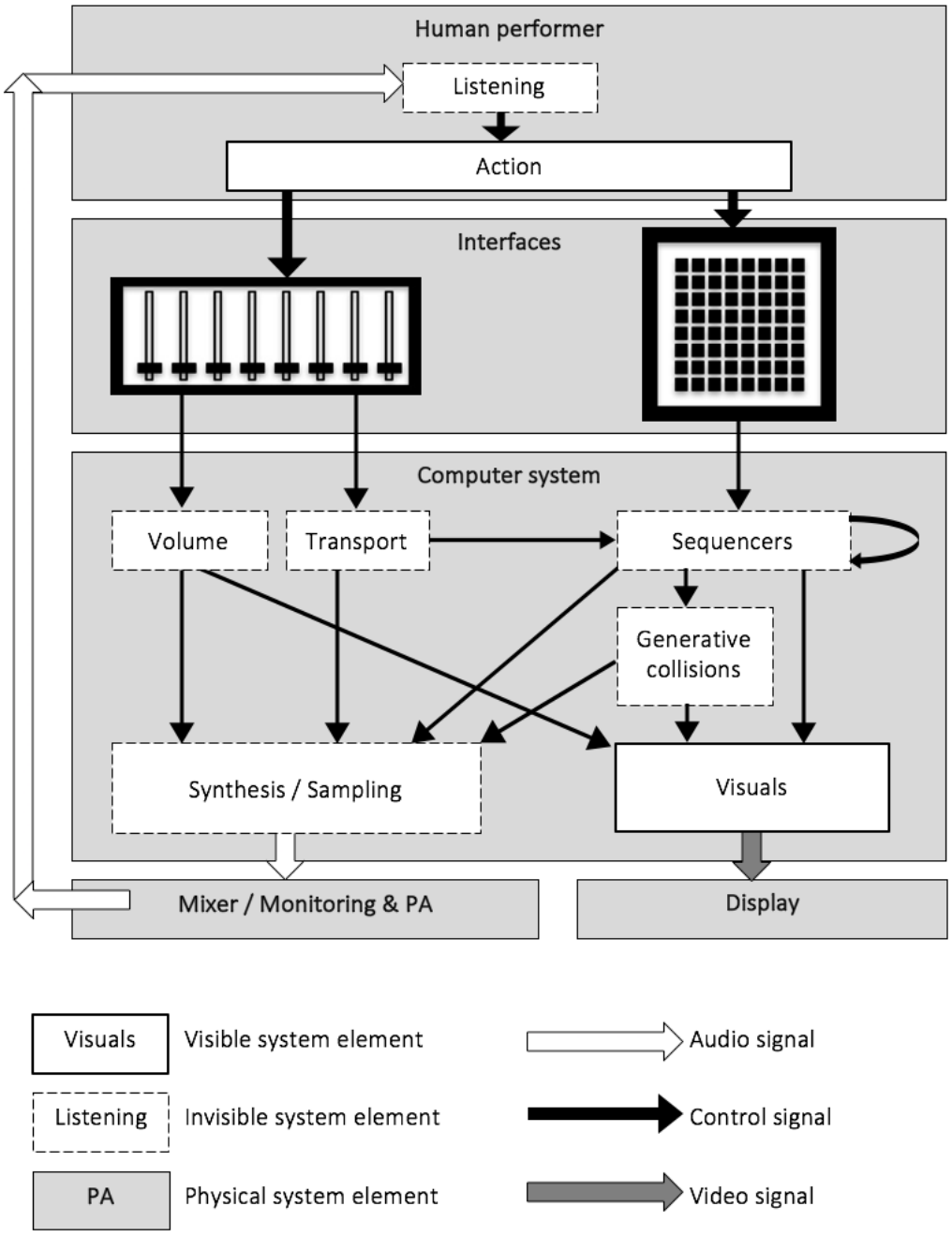

*Figure 14: System architecture for the 'explorative-generative' pieces. The second piece using this approach, (*I Begin Where You End*) also featured live vocals and additional effects. The curved arrow represents the ability for intermodulation between sequencers.*

3.2.2.2. System visuals

The visuals were designed to replicate the functioning of the *Launchpad*, with a few variations designed to facilitate audience understanding. First, the brightness of the red squares representing arpeggiators (red squares in Figure 15) are controlled by volume faders on the *Nanokontrol* so that they can only be seen when the corresponding sound is audible. Second, the vertical movement of green squares was made continuous rather than stepped to represent the continuous oscillation of an LFO and to contrast with the event-generating movement of the red squares. Third, generative collisions between the red and green squares are highlighted (white square in Figure 15), as are collisions between user-activated squares and green pulses (yellow, hollow squares).

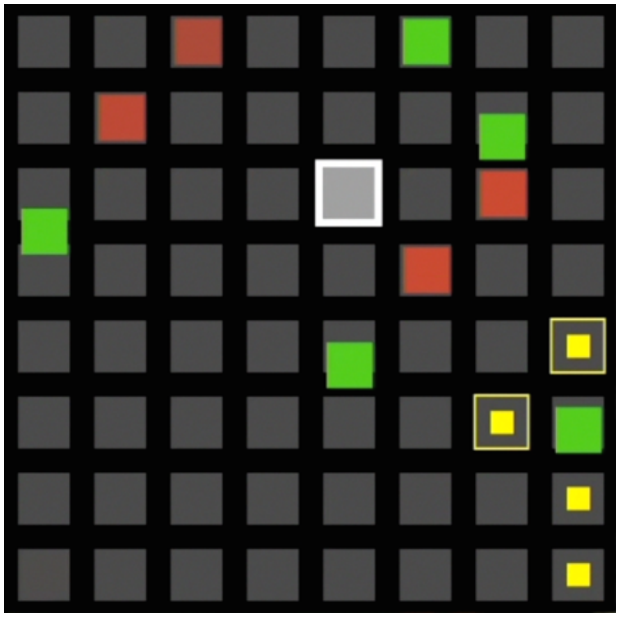

Figure 15: System visuals for the 'explorative-generative' pieces replicating the Launchpad *interface and the system behaviour.*

3.2.3. Rows, Columns, Collisions

3.2.3.1. Overview and description

The initial composition with the 'explorative-generative' system approach is an open-ended exploration of the capabilities of the complex sequencing tool. The inclusion of popular music features was therefore less important than free and spontaneous compositional decisions (White, 2005).

The piece begins with a repeated piano note, triggered by a pulse on the top row. The speed of this pulse is modulated by the first column. More piano notes are then introduced, each triggered by events on the second, third and fourth rows and modulated by corresponding columns. As more layers are introduced, the likelihood of collisions between rows and columns increases. Each collision triggers an unpitched, textural noise sample, creating a constantly changing background layer. In the second section (3m 05s), most of the piano sounds are faded out and the four right-most columns are activated. User pads on these columns are then held down to create melodies, with the timings between the notes constantly varying due to the different speeds and directions of the columns. Following the reintroduction of the original piano sounds (4m 27s), elements are gradually faded out until the piece concludes as it started, with one piano part being modulated by a single column.

Live recording, playback and granular synthesis of the system output are used to create an additional background layer. This constituted an additional compositional decision rather than a feature of the system, though further development of the piece could link recording, playback and granular synthesis parameters to the movement of rows and columns.

3.2.3.2. Composition process

The composition process began with the development of the software, with no pre-conceived ideas of what the piece should sound like. The software was initially created in

Max, with Live running as a ReWire application (Propellerheads, n.d.) for audio playback and recording. An array of *send* and *receive* objects enabled intermodulation between the rows and columns. The tool was eventually rebuilt as a Max for Live device to enable quicker setup, more routing flexibility and the ability to link parameters using Live's application programming interface (API) (Cycling '74, n.d.).

To maintain clarity between system functioning and audio output, row pulses are used for short-duration sound events, column pulses for modulating the behaviour of rows and collisions between them for textural layers. In keeping with the aesthetic of the piece, the samples used to create these textures were selected using an offline algorithmic process. Using a set of existing recordings on CD, the dying moments (from the final transient to silence) of the fourth track on every eighth disc was sampled. These samples were then organised by length and noisiness. The longer, noisier samples were further edited and used for the textural layers in the piece.

3.2.3.3. Conclusions

Similar to other systems such as *Kinetic Engine* (Eigenfeldt, 2008) and *Nodewebba* (Battey, 2014), *Rows, Columns, Collisions* demonstrates the ability of a generative system to produce music of considerable complexity and unpredictability that suggests coherence rather than randomness. Although it achieved some of the artistic goals listed in Chapter 1 through exploration of the system's capabilities, the piece was not considered to be a song and was therefore not developed beyond an experimental sketch. The next 'explorative-generative' piece therefore aimed to use the system to create a complete song.

3.2.4. I Begin Where You End

3.2.4.1. Overview and description

Taking its title from the algorithmic sample selection process described in 3.2.3.2, the second 'explorative-generative' piece incorporates popular song features such as vocals, harmonic and melodic motifs, a clear pulse, drum tracks and distinct verse-chorus sections.

The system was used for improvising with sampled material at the initial stage of composition before using a digital audio workstation (DAW) for further composition, arrangement and production. Following the completion of the recorded version, the system was used again to create a live version. The potential to recreate composition conditions through the use of the system's sequencing capabilities (rather than using material taken directly from the recorded version) resulted in a radically different live version.

Similar to *Rows, Columns, Collisions*, *I Begin Where You End* features the gradual introduction of sound events triggered by rows and modulated by columns. The collisions between rows and columns also trigger sample playback. The incorporation of multiple sample patterns on the same row led to the 'user' pads being used to switch patterns (e.g. 1m 01s) as well as to program drum parts (e.g. 4m 24).

3.2.4.2. Composition process

Samples gathered from the algorithmic process used in *Rows, Columns, Collisions* were organised and edited to create chords, short noise bursts, percussive and bass sounds before implementation into the system. A period of exploration and improvisation on the system followed that established the main musical ideas (National Trevor, 2012). The material was then imported into a DAW for further arrangement work to create a recorded version (National Trevor, 2014b). Material from experimentation with other generative software

tools (an early version of the system for *Leave My Room*) and collaborations with a vocalist and drummer[4] was also incorporated.

Figure 16: Improvising with the system in the composition of I Begin Where You End*. Still from video available at https://www.youtube.com/user/NationalTrevor and is author's own.*

The system was then reintroduced in order to create a live version of the piece. The vocals, and melodic sample sequences were retained, whilst alterations were made to other aspects of the piece in order to minimise the use of pre-sequenced material. For example, drum parts are re-programmed by the performer during the performance; the bassline is a walking bass pattern triggered by one of the row pulses acting as an arpeggiator (1m 25s) and noise bursts are triggered by row-column collisions. The last section of the recorded version was removed as this had been created in the DAW rather than through improvisation with the original system and was not considered essential for the live version of the piece.

[4] Roxana Vilk (vocalist) and Peter Vilk (drummer) from the band GOL. See http://petevilk.com/gol-audio/

3.2.4.3. Conclusions

I Begin Where You End demonstrates the use of the 'explorative-generative' approach for both the initial creation of a piece of popular music and the subsequent development of a live version from a fixed, recorded version. Use of the system led to the inclusion of qualities indicating cerebral sensuality (identified in Chapter 1), such as complex phrase relationships and ambiguous rhythmic structures. However, performing on the *Launchpad* felt awkward compared to using a guitar and sharp sectional changes were difficult to achieve. The next system approach therefore used signal analysis and score-following techniques to enable interaction with the system while playing guitar.

3.3. Multi-tool systems for guitar and vocal performance

3.3.1. Introduction and background

3.3.1.1. Interactive systems in traditional guitar/vocal performance

The three pieces created with the 'multi-tool' approach investigated the use of interactive systems in a more traditional singer-songwriter context. The use of signal analysis and score-following techniques allow the human performer to play guitar and sing rather than operate controllers. The systems' response components include multiple Max for Live devices creating melodic, harmonic and/or rhythmic accompaniment. Though unpredictable, the output of the devices within these systems were constrained in order to be compatible with the composed features of the song. These constraints were applied through the use of representational data from the instrumental/vocal audio signal, score-following techniques and sequenced material.

Similar work in this field includes *Reactive Backing* (Cycling '74, 2016), which allows real time tempo, dynamic and playback control of sequenced material and *Reflexive Looper* (Marchini et al, 2017), which removes the need for pre-sequenced material through combining live looping, score-following and real-time pitch shifting.

3.3.1.2. Signal analysis

Interactive music systems involving instrumental/vocal performance may be controlled through the use of real-time audio analysis algorithms which create representational data from the audio signal (Stark, 2014). This removes the need for complex, sensor-based systems (Johnston et al, 2008), additional controllers (Waite, 2011; Donovan and McPherson, 2014) or physical modifications to instruments (Kristensen, 2012).

There are many well-documented resources for creating signal analysis tools in Max or Live (Puckette, 1998; Jehan and Schoner, 2001; Schnell et al, 2005; Malt and Jourdan, 2008; Reboursière et al, 2010; Schnell, 2013; Stark, 2014). Many of these tools use the *Yin* algorithm for fundamental frequency calculation (de Cheveigné and Kawahara, 2002), which has proven robust and reliable compared to other methods (Pardue et al, 2014). However, like all methods relying on autocorrelation functions, it can be less reliable at lower frequencies with low latencies (Rowe, 1993) and can be computationally expensive (Stark, 2014). Jam Origin's *MIDI Guitar* software (Jam Origin, 2017) claims high accuracy at low latencies for monophonic and polyphonic analysis by comparing incoming audio events with stored reference fragments (Kristensen, 2012). Combined with the ability of the software to detect note velocities, this removes the need for additional hardware such as hexaphonic or MIDI pickups.

3.3.1.3. Score-following

A key attribute of interactive systems is whether they are performance- or score-driven (Rowe, 1993; 2004). Performance-driven systems are designed to be highly responsive to performer input and used across multiple compositions or improvisational situations. Score-driven systems change their response according to the position within a piece, either in response to triggers from a controller or automated score-following. Score-following approaches include:

- The use of machine learning to recognise real-time performance gestures as in *Wekinator* (Fiebrink, 2009) and *Gesture-Follower* (Bevilacqua et al, 2009).
- The continuous synchronisation of live audio with a fixed score as in *Antescofo* (Cont, 2008)
- The classifications of playing modes as in *Reflexive Looper* (Marchini et al, 2017).
- The use of triggers derived from the results of signal analysis, such as the detection of a signal amplitude above a threshold (Winkler, 2001; Husbands et al, 2007).

In popular songwriting, the detection of transitions between verse, chorus and bridge sections will be particularly useful due to the potential for harmonic, rhythmic and dynamic shifts between these sections. Detecting these transitions can instantiate a series of *structure-constraints* (Marchini et al, 2017) that change the system's response according to the current detected section. As well as ensuring appropriateness of system response throughout the piece, this strategy also allows the performer to vary the length of each section.

3.3.1.4. Response algorithms in interactive systems for popular music

As discussed in 1.1.2, interactive system response algorithms can be generative, transformative or reflexive. Among the huge number of Max-based tools that make use of generative algorithms are the *Kin.rhythmicator* for rhythm generation (Sioros and Guedes,

2011); *Patter* for rhythm and note generation (Florin, 2015) and the looper section of *Multimodal Guitar* for randomised playback of recorded audio (Reboursière et al, 2010). All of these devices have real-time controls that can be mapped to performance data to control aspects such as note density, randomness and syncopation.

Transformative processes act directly on the live input. For example, on the song *Pulk/Pull Revolving Doors* (Radiohead, 2001), Thom Yorke used an autotuner on a spoken vocal to generate unpredictable melodies (Reynolds, 2001). Transformative processes are also used extensively in augmented instruments such as *Multimodal Guitar* (Reboursière et al, 2010) and Ben Neill's *Mutantrumpet* (Bill Jones, 2009).

Reflexive systems record, process and playback fragments of a live performance and are therefore particularly useful for improvisation situations (Lewis, 2000; Pachet, 2006). For example, John Biles' *GenJam* is a reflexive system for the performance of traditional jazz (Biles, 2013), where human and machine performers trade improvised solos. Reflexive processes are also useful for generating additional accompaniment layers from the live instrumental/vocal audio (Marchini et al, 2017), particularly when combined with generative techniques (Gifford and Brown, 2011).

3.3.1.5. Audio and visual outputs

When interactive systems are used in combination with human instrumental/vocal elements, several factors affect the overall design of a system's audio and visual outputs. First, where the system is being used to create a live version of an existing piece of music, there may be some pre-sequenced material that is deemed essential. If this material is a recording of a human performer, its use may serve to highlight the absence of the human performer rather than enhance the performance (Demers, 2010). Second, if the system is generating electronically produced sound, these sounds need to sufficiently relate to the vocal and instrumental elements for the perception of the performance as a cohesive whole (Winkler, 2001; Estibeiro, 2016). Finally, the visuals can be designed to reveal the mechanisms by

which the system is generating audio output and interacting with the performer (Hansen, 2005; Toplap.org, 2010; Biles, 2013).

In the 'explorative-generative' pieces, the system could be easily replicated in the visuals. In the 'multi-tool' approach however, there were multiple, non-visual processes to represent, requiring the creation of a unifying design concept. Potential solutions included the anthropomorphisation of the machine performer (Backes, 2015; Kirn, 2015a) (Figure 17) and the use of synchronised audio and video recording and playback (Marchini et al, 2017) (Figure 18).

Figure 17: Martin Backe's installation What Do Machines Sing Of? *The white bar acts as the system's 'mouth' and changes shape in synchronisation with vocal synthesis. Photo by Martin Backes (2015). Used with permission*

Figure 18: Francois Pachet (centre of picture) performing with the Reflexive Looper. *The video screens play back recorded video synchronised with audio loops. Still from video by Sony CSL (2016). Used with permission*

Having introduced the key components for interactive systems for popular music involving live instrumental/vocal performance, the next section will discuss the implementation of these components in the systems for the 'multi-tool' pieces. Bespoke devices for each of the three pieces will be discussed in 3.3.3-3.3.5.

3.3.2. System architecture

3.3.2.1. Overview

Figure 19 shows the system architecture for the pieces used in the 'multi-tool' approach, illustrating the co-presentation of human and system audio output; the use of the human performer's audio signal to control system behaviour through data scaling and score-

following; the use of multiple devices to generate audio output from instrumental/vocal audio and the representation of these processes in the system visuals.

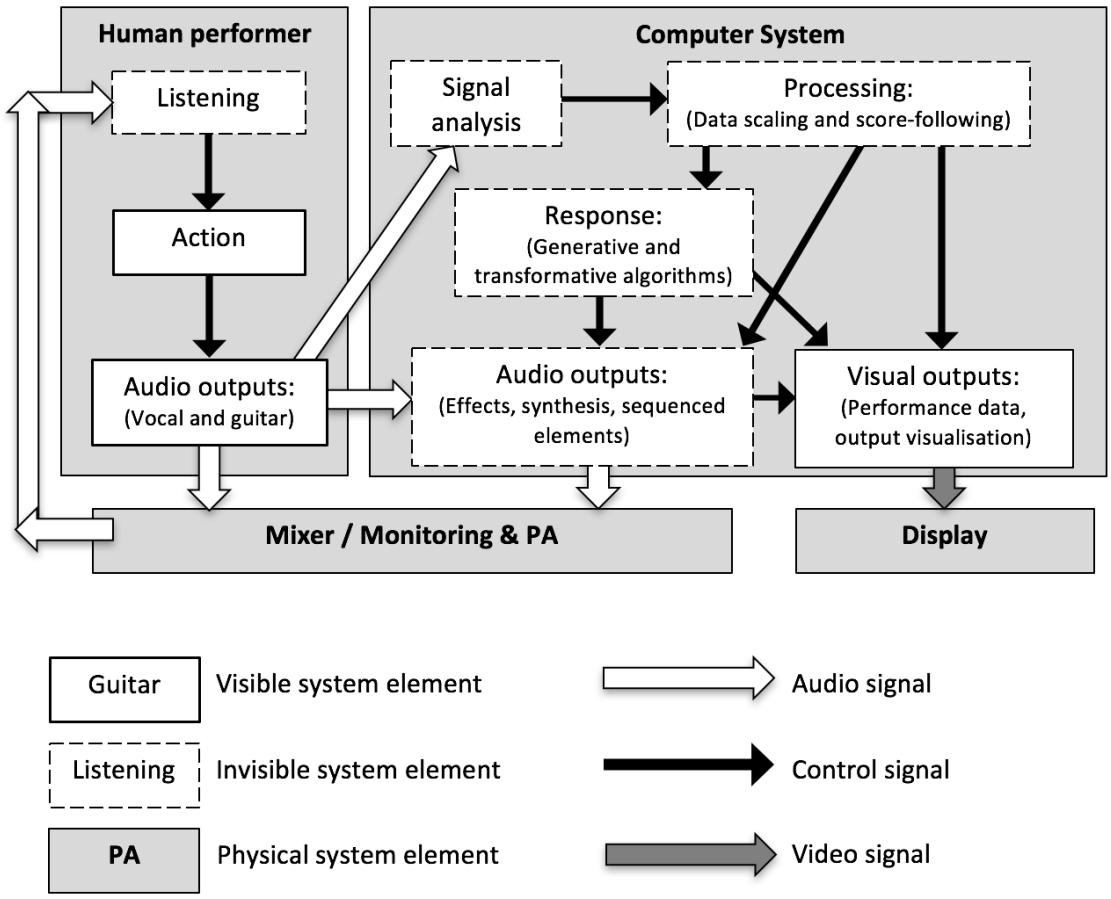

Figure 19: System architecture for the 'multi-tool' systems.

3.3.2.2. Input: Instruments as controllers

The 'multi-tool' pieces use the human performer's live guitar and vocal audio signal as the sole control method. Jam Origin's *MIDI Guitar* software is used for reliable pitch-tracking in conjunction with Max externals that detect the frequency content[5] and level[6] of incoming

[5] *analyzer~* to extract levels for specific frequency bands

[6] *average~*, *line~*, *deltaclip~* and *slide~* for amplitude and level analysis

audio. Performance data such as guitar pitch and signal level is then further processed to create control parameters for effects and triggers for score-following.

3.3.2.3. Processing: Score-following

The score-followers for the pieces in the 'multi-tool' systems and 'metaphor' systems were developed in Max. The similarity of rhythmic and harmonic structures within the songs' sections and the requirement for flexibility in performance meant that the score-followers were designed to detect sectional boundaries (i.e. between introductions, verse, chorus etc.) rather than follow a fixed score. The approach was further simplified by the reliability of pitch data from *MIDI Guitar*, which removed the need for machine learning approaches.

The sectional approach used in the 'multi-tool' and 'metaphor' pieces results in the detection of the current song section, which applies a series of structure-constraints (Marchini et al, 2017). These create variation in the systems' audio and visual outputs as the song progresses, while ensuring that indeterminate audio output does not disrupt the composed elements. Triggers for detecting sectional changes were created from analysis of the real-time performance data which included:

- Detection of a specific sequence of pitches in the guitar part.
- Harmonic analysis of the guitar part over a set period of time.
- Detection of the guitar/vocal audio signal above or below a specific threshold.
- Tracking the behaviour of system elements.
- Tracking bar and beat position for time-critical triggers.

Robustness was increased through the use of a feedback loop which restricts the score-follower to detecting sections in specified sequences and by combining triggers using logical expressions. Additional flexibility was achieved by counting the number of detections of each section, which enabled the differentiation between instances of the same section and facilitated further variation in the systems' responses.

3.3.2.4. Response algorithms and audio outputs

While the use of sequenced material was kept to a minimum, some of the parts from the recorded versions of the songs were deemed essential for inclusion in the live versions. *Unquiet* and *Brains Need Bodies Too* feature percussion tracks and bass parts controlled by the score-followers. In all of the 'multi-tool' pieces, bespoke devices were developed to create accompaniment using generative, transformative and reflexive processes. These will be described in the discussions of the individual compositions in 2.3.3-2.3.5.

3.3.2.5. System visuals

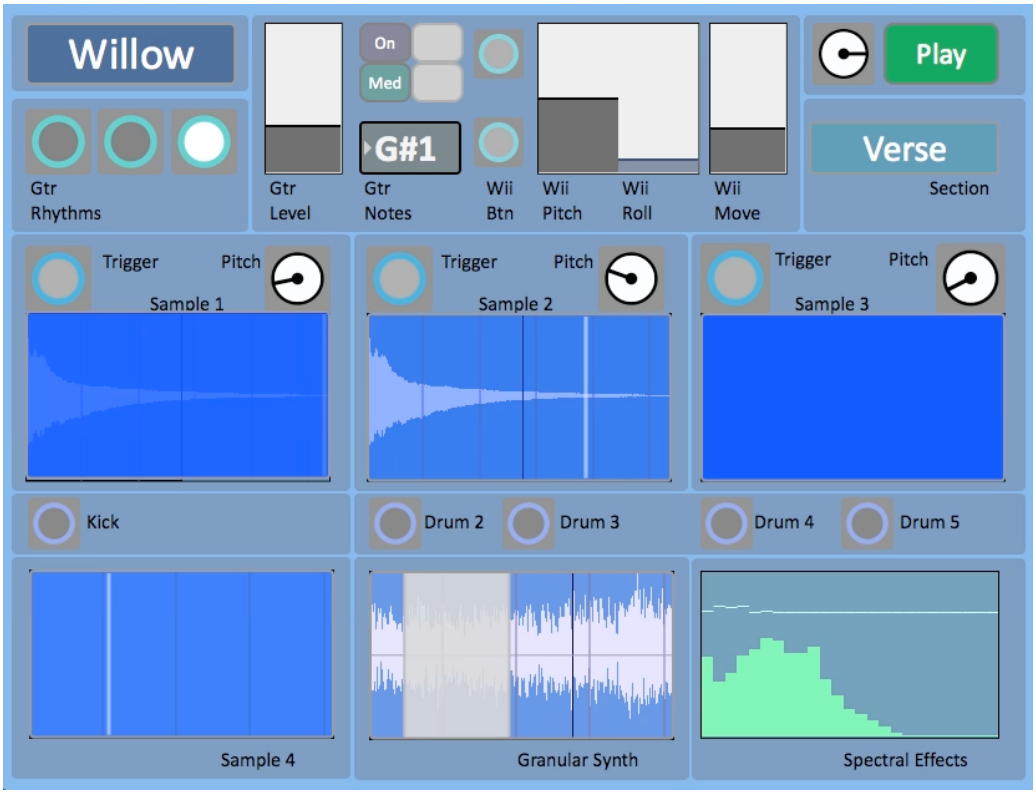

Figure 20: Early system visuals for Willow *showing various system inputs, processing and outputs.*

The visuals aimed to reveal the systems' behaviour to the audience and achieve the *technological sublime*, meaning that the machine becomes an aesthetic object in its own right (Demers, 2010). As mentioned in 3.3.2.5, combining multiple tools and processes into a coherent entity required the creation of an overall design principle. The first attempt

(National Trevor, 2014b) aimed to present the audience with a stripped down version of a user interface built with Max objects (Figure 20). This approach was abandoned as it was aesthetically unsatisfactory, presented an overload of input/output information to the audience and did not reveal underlying system processes or wider connections to song themes. It was replaced by the unifying concept of the head-up display (HUD), a popular conception of what the inside of a computer entity looks like: either looking out (*Terminator 2*, 1991; *Wall-E,* 2008) or looking in (*Transcendance*, 2014). The computer's vision of the human performer was displayed via the webcam, flanked by human input on the left and system output data on the right. The modules of the HUD include:

- Filtered computer vision of the human performer.
- Bar charts showing live MIDI note data and audio levels.
- Continuously scrolling text showing input levels.
- Song lyrics scrolling in time with vocal input.
- A grid representing a drum pad visualising percussive outputs.
- Computer code scrolling in time with the systems' percussive outputs.
- Current song section displayed when changes occur.
- Current date, time and bar/beat position.

Variations were created for each of the three pieces to represent the different system components. Images of these are therefore presented in the individual piece discussions.

3.3.3. Willow

3.3.3.1. Overview and description

Willow begins with an arpeggiated guitar chord played over a four-to-the-floor kick drum. This riff is automatically recorded and used to create a textural layer using granular synthesis (0m 20s). A single note is then recorded (0m 32s) which is used by two variable-speed

loopers to generate accompanying melodic patterns. A third looper plays back the same recording in response to the detection of a loud high note (e.g. 1m 38s), and a spectral freezing effect is activated when the overall guitar playing level exceeds a specified threshold (e.g. 1m 37s). These layers are featured throughout *Willow's* introduction, verse, chorus, final verse and outro, which all feature the same chord progression. The bridge section contains a key change that begins with a descending bass note run (3m 01s). The guitar part at the end of this section is recorded (3m 37s), looped and transposed to accompany the final sections of the piece (3m 43s).

Figure 21: System visuals for Willow.

Figure 21 shows the system visuals based on the HUD approach discussed in 3.3.2.5. The human performer elements are on the left and representations of the system audio output are on the right. The blue tint on the video input was selected to distinguish the piece from

other 'multi-tool' pieces and to allude to the blue and white of the *Willow Pattern* (Birks, n.d.), which provides the basis for the song's lyrics.[7]

3.3.3.2. Bespoke system components

Figure 22 shows the playback device used to generate additional melodic layers throughout the piece, and to loop the recorded section of the bridge over the final sections. The device was built around the *groove~* object referring to a *buffer~* object contained within a separate device, enabling multiple playback devices to refer to the same recording.

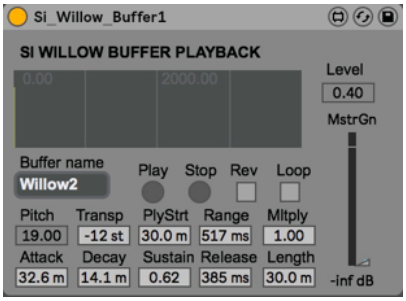

Figure 22: Playback device for Willow *showing playback, pitch, envelope and level controls.*

Figure 23 shows the spectral processing device that combines spectral freezing (Charles, 2011) with amplitude filtering (dude837, 2011) to create an additional effects layer that is activated whenever the guitar signal exceeds the loud threshold.

Figure 24 illustrates one of the devices that creates drum patterns from the guitar input. MIDI notes created from the guitar signal are recorded into one of Ableton Live's clips and looped every time a sectional transition is detected. The output of the clip is then parsed (by note range) and rhythmic density reduced before mapping to drum sounds. An additional

[7] *Willow's* lyrics describe the story of the *Willow Pattern,* in which a young woman is imprisoned by her father. Rescued by her lover, the couple escape to an island, where they are eventually found and killed, before being reborn as bluebirds. See 7.4 for the complete lyrics.

rhythm-generating device records and plays back note delta times using the *coll* object (Winkler, 2001).

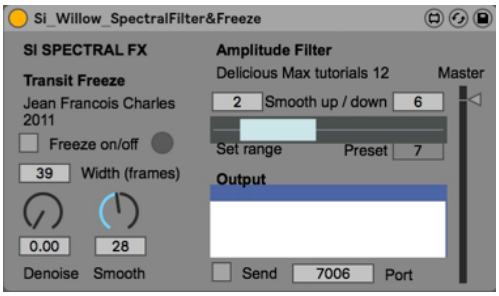

Figure 23: Spectral processing device used for level-dependent guitar effects in Willow.

Figure 24: Parsing and thinning device for converting recorded guitar input into drum parts.

3.3.3.3. Composition process

Willow was originally intended to be performed with a variation of the system used in the 'explorative-generative' pieces. Initial experimentation was done with this system, which led to the chord progression, vocal melodies and eight-bar phrase lengths used in the verses and choruses. However, the need for a suite of devices that could produce audio output from instrumental input and vary their behaviours according to song position led to the development of an entirely separate system.

Having created verse and chorus sections that could be detected by their harmonic content and distinguished by playing level, a bridge section was written that included a bass note run and a distinct harmonic shift. This would be straightforward for a score-follower to detect.

The lyric-writing process followed the modernist approach of prioritising the sonic characteristics of words over their meaning (Bense, 1966; Reich, 2002) which in turn suggest melodies (Citron, 1985). This process was repeated until a sonically- and melodically-interesting vocal part had been written. To transform the nonsense lyrics into something more meaningful, themes related to the nonsense words were brainstormed and researched, eventually leading to the story of the *Willow Pattern* (Birks, n.d.). The lyrics were then reworked to retain their original sonic characteristics whilst referencing the *Willow Pattern* story. This thematic exploration also led to the use of recordings of chinaware as the source material for the percussion samples.

3.3.3.4. Conclusions

Willow demonstrates how real-time, indeterminate processes can be combined with conventional popular song features and expressive performance using a minimum of pre-sequenced material. However, while the system's exact behaviour is unpredictable, its interactivity is compromised due to the response devices being controlled directly by the human performer, the score-follower and constraints written into the system. This may result in lower levels of interactive liveness and reduces the potential for each performed version to be unique. A further limitation is that only the guitar input is used as a real-time sound source. The subsequent pieces in the portfolio therefore explored ways to increase the performative agency of the system and ways to utilise vocal input as a sound source for system audio output.

3.3.4. Unquiet

3.3.4.1. Overview and description

Before the implementation of an interactive system, *Unquiet* existed as a demo recording with lead vocal, guitar, bass guitar and drum parts. The system was introduced in order to develop the song's arrangement through the real-time generation of a synthesiser part and backing vocals.

The drum and bass guitar parts from the demo recording are incorporated as pre-sequenced elements and are controlled by a score-follower. As the bass part was an audio recording of a bass guitar, it is overlaid with a synthesiser to give it a machine-like quality and therefore maintain distinctiveness from the human performer (Auslander, 2000; Demers, 2010). The real-time synthesiser part is provided by *Gen_Arp,* a Max-based interactive-generative arpeggiator (Waite, 2013), that was adapted and converted to a Max for Live device. Backing vocals are generated using a bespoke live looping device.

Figure 25: System visuals for Unquiet.

Figure 25 shows the configuration of the HUD visuals for *Unquiet*. The MIDI outputs of *Gen_Arp* (top right) and the bass synthesiser (bottom right) are represented with the level of the backing vocal outputs (to the left of the drum pads) also included. A sepia tint was applied to the camera input to reflect the lyrical themes of nostalgia and old age.

3.3.4.2. Bespoke system components

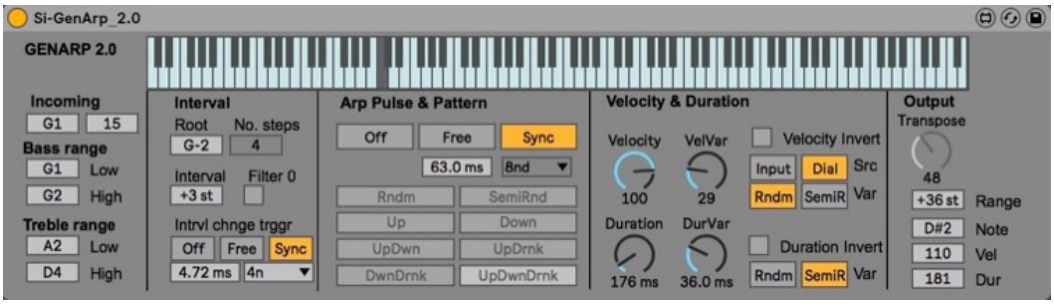

Figure 26: Gen_Arp *Max for Live Device as used in* Unquiet.

Gen_Arp (Figure 26) creates arpeggiated note sequences in response to real-time MIDI notes. Pitch values generated from the live guitar input by *MIDI Guitar* are passed to the input of the device, which calculates the interval between the lowest two pitches within the 'Treble range'. It then generates a sequence of pitches based on this interval, beginning on the 'Root': the currently detected bass note within the 'Bass range'. The 'No. steps' parameter determines the length of the arpeggio. Further parameters include pulse speed, pulse pattern, note velocity, velocity variation, note duration and duration variation. To avoid harmonic clashes and increase unpredictability, the notes in the arpeggios are filtered according to the desired scale using Live's *Scale* device. The unwanted notes are either removed to create rhythmic variation or wrapped to create melodic variation.[8]

[8] A demonstration of the original *GenArp*, a standalone tool built in Max, is available at https://www.youtube.com/watch?v=CSFmOhS0ChA

Figure 27 shows the Max for Live device used to generate backing vocal layers from the live vocal input. This works by using automatic, level-dependent recording into two buffers in order to generate a continuous audio output, with envelope parameters controlled by the score-follower. Its overall level can be linked to the live vocal through the 'Master Env' settings. This enables the device's output to remain in the background when the lead vocal is present, create a call and answer effect during breaks in the vocal parts and produce continuous, foregrounded output during instrumental sections (e.g. 2m 33s).

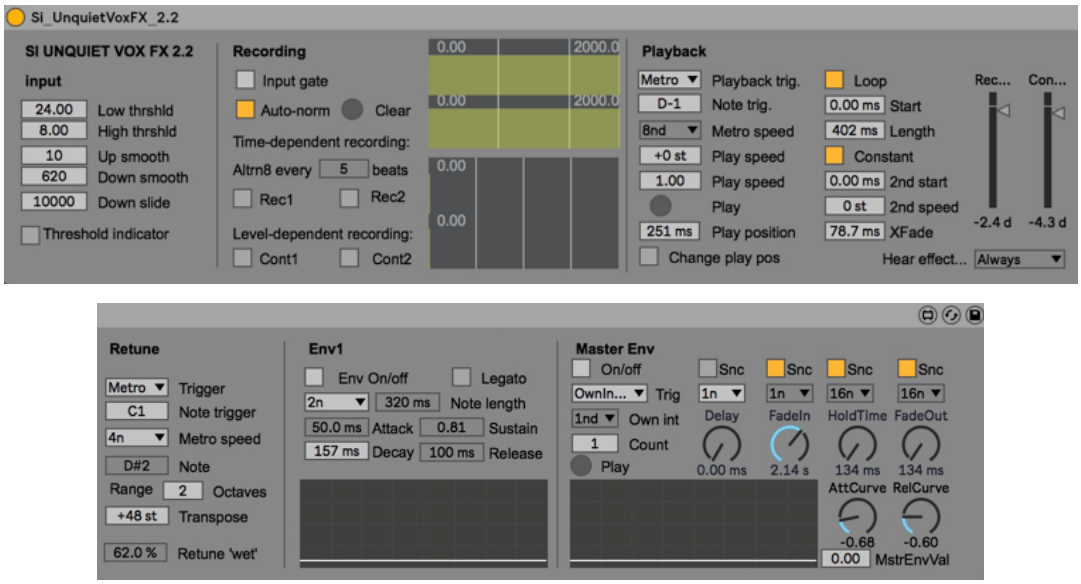

Figure 27: Max for Live device for creating backing vocals from live input (shown in 2 parts).

3.3.4.3. Composition process

Once the standalone *Gen_Arp* tool had been converted to a Max for Live device, it was connected to a synthesiser to appropriately sonify its MIDI output in the context of the song. Multiple parameters of both *Gen_Arp* and the backing vocals device were mapped to the score-follower in order to emphasise sectional changes as the piece progresses, which are indicated by the greyed-out parameters in Figures 26 and 27.

3.3.4.4. Conclusions

Unquiet incorporates indeterminate techniques into two Max for Live devices that generate a synthesiser part and backing vocals from the live guitar and vocal. The control of these devices by live performance data and the score-follower creates variation throughout the song. This enables the synthesiser part and backing vocals to become prominent features in the arrangement and emphasise sectional changes without detracting from the composed elements. However, the use of pre-sequenced material and strict score-following requires the performer to perform precise triggers in the guitar part at precise times, which reflected a focus on achieving an ideal performance over expressive interaction with the system. Furthermore, other than the sepia tint to the visuals, there were no thematic links between the song and the system's audio and visual outputs.

3.3.5. Brains Need Bodies Too

3.3.5.1. Overview and description

Brains Need Bodies Too aimed to build on the strengths and resolve the shortcomings of the previous two pieces. First, the song's themes of human-machine tensions are represented by the system processes and visual outputs (Figure 28) as well as the music and lyrics. Second, both live guitar and vocal input generate additional, heavily processed reflexive layers that communicate a machine aesthetic and enhance the separateness of the system from the performer. Third, pre-sequenced drum and bass parts respond directly to real-time guitar input and generative processes as well as the score-follower in order to achieve more variation and interactivity. Fourth, machine learning processes were implemented in some devices to allow the system to feature more prominently in performance and increase overall levels of interactivity. For example, towards the end of the piece (3m 40s), the system learns the melody being played on the guitar, enabling it to lead the improvisation with the human performer and gradually become the dominant melodic element.

Figure 28: System visuals for Brains Need Bodies Too*.*

3.3.5.2. Bespoke system components

The live guitar part is processed by two effects chains, positioned on the left and right side of the stereo field. The left chain includes a looping device (Figure 29) that records and plays back the live input with stochastic controls (on the right of the device). The right chain achieves a similar effect using the Max for Live devices *Buffer Shuffler* (that re-orders, reverses and silences the contents of continuously-changing audio buffer) and *Max CutKiller* that introduces silence of varying duration into an audio stream. This theme of interruption is continued through the use of an original device that generates short noise bursts (Figure 30).

Figure 29: Live looping guitar effect with stochastic parameter controls.

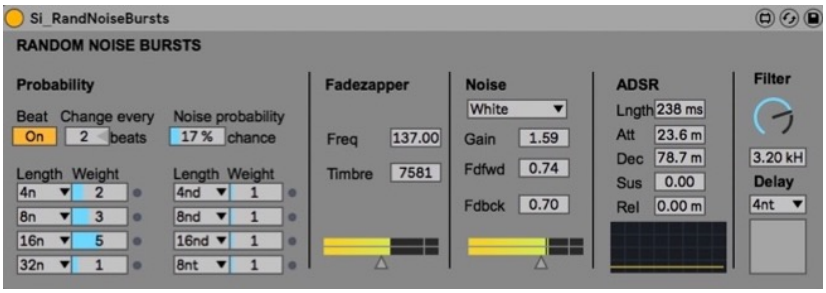

Figure 30: Stochastic noise bursts device on the guitar effects channels.

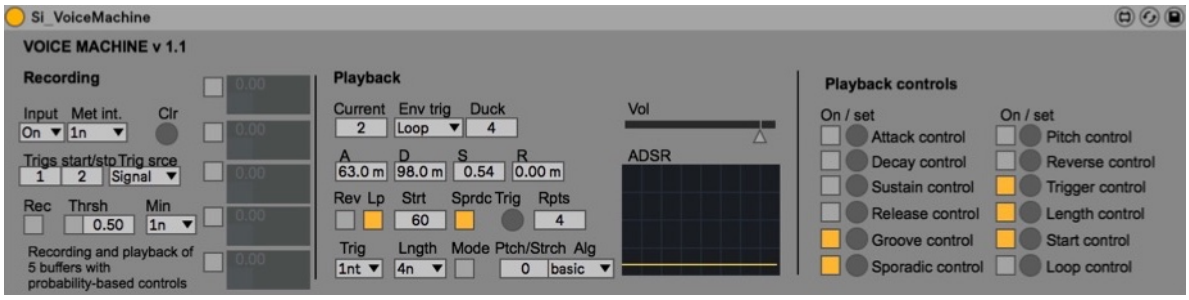

Figure 31: Vocal live looper with multiple buffers and stochastic parameter controls.

The live vocal is processed by a multiple-buffer looping device (Figure 31) that allows up to five short vocal fragments to be stored and played back, establishing a non-linear time relationship between the sung and machine vocal. Similar to the guitar effects, stochastic controls over the playback functions creates additional variation. To further enhance the glitchy, machine-like aesthetic, the vocal looper's output is processed by a device that applies pitch shifting and sample and hold effects at stochastically-controlled intervals (Figure 32).

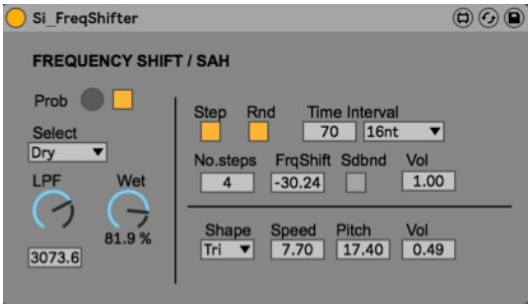

Figure 32: Frequency shifting /sample and hold effect on the vocal effects channel.

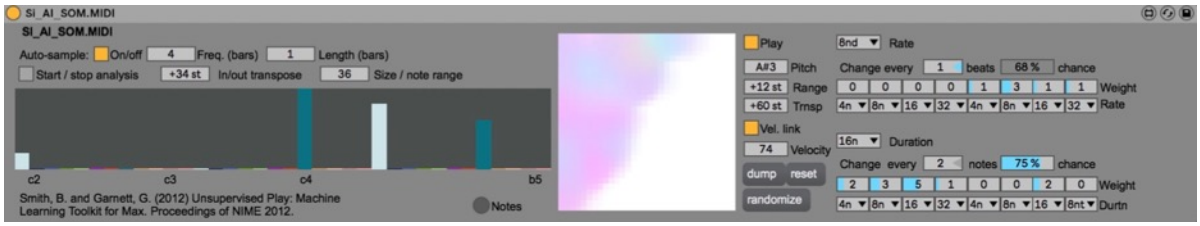

Figure 33: Max for Live Device using a self-organising map to generate melodic accompaniment.

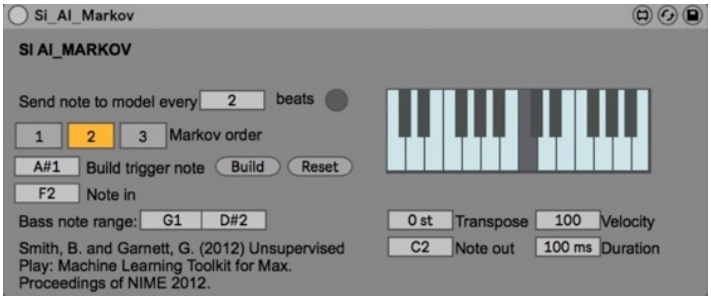

Figure 34: Max for Live Device using Markov chains to learn and play back a melody.

Towards the end of the piece, the system exerts more influence through the use of devices incorporating machine learning Max objects (Smith and Garnett, 2012; Smith 2018). One device uses a self-organising map (SOM)[9] to generate a melodic accompaniment based on the guitar input throughout the piece (Figure 33). The other device uses Markov chains[10] to learn and play back the melody played of the bass notes of the guitar part. (Figure 34).

[9] SOMs are unsupervised learning models that store multidimensional input data in a two-dimensional map. When input values are presented, the closest values on the map are returned (Smith and Garnett, 2012).

[10] Markov chains predict sequences of values (e.g. pitch values) based on previous occurrences (Smith, 2018).

The bass part in *Brains Need Bodies Too* is largely pre-sequenced. However, in the bridge section (3m 04s), a modified version of *Gen_Arp* was used to create an indeterminate bassline. In the improvised sections at the end of the piece, while the rhythm was pre-programmed, an additional Max for Live device enables the pitches to follow the bass notes of the live guitar.

3.3.5.3. Composition process

As with *Willow*, the system was implemented when only the guitar part and vocal melodies for the verse and chorus had been written. This allowed the system to inform the subsequent development of the piece. The HUD visuals approach had been established prior to lyric-writing and therefore informed the song's themes: an exploration of the pervasiveness of technology in everyday life. This theme prompted the inclusion of machine learning processes. Towards the end of the piece, a Markov model attempts to learn and play back the sequence of the bass notes of the live guitar part. Inspired by a legendary Pink Floyd rehearsal, in which Syd Barrett deliberately confused his bandmates by changing the melody and arrangement of a new song each time they ran through it (The Bigfoot Diaries, 2015), this sequence continuously varies. As the Markov model plays back the melody, the human performer follows its imperfections, thereby deliberately introducing more errors into the process and setting up a situation in which the human and machine performers are (unsuccessfully) trying to follow each other.

3.3.5.4. Discussion and recommendations

Brains Need Bodies Too was successful in terms of the strong thematic connections between system and song; the use of both guitar and vocal audio in the system's audio output and increased interactivity through the real-time manipulation of sequenced material and the use of machine learning. However, although the human and machine elements combined well to

create a popular song with intriguing experimental leanings, like the other the 'multi-tool' pieces, the use of the system does not significantly influence the deeper structure of the song. Furthermore, while the HUD approach revealed the system's inputs and outputs in a stylised way, it did not reveal much about the system's underlying processes and risked information overload. The 'typing' and 'metaphor' system approaches address these issues and will be detailed in 3.4 and 3.5.

3.4. 'Typing' pieces

3.4.1. Introduction and background

3.4.1.1. Links between text and music

Techniques to generate music from text date back to Guido's 11th century algorithmic method for composing chant melodies based on counting vowels (Rowe, 1993). More recently, Alsop (2017) discusses a strategy for generating ten musical parameters from ASCII code when converting text passages to electroacoustic music. Davis and Mohammad (2014) describe the *TransProse* system, in which music is automatically generated by analysing the emotional activity of a novel and mapping it to musical parameters. Rangarajan (2015) discusses specific strategies for extracting pitch and rhythm from text that include using all of the letters, using just vowels and using punctuation. In performance settings, real-time text-to-music techniques include live coding (Nilson, 2007), the real-time generation of scores (Freeman, 2011) and the use of speech recognition software (Rouas et al, 2013).

3.4.1.2. Links between typing and musical performance

Performative links between typing music are well established. Hirt (2010) and Feit and Oulasvirta (2013) point out the similarities between typing on a keyboard and playing the piano. Merrett (2007) and Fallgatter (2013) demonstrate how parallels between typing proficiency and instrumental virtuosity can influence the design of expressive, versatile digital musical instruments that do not require extensive practice by the user (Kirn, 2004). Fiebrink et al (2007) highlight the suitability of the computer keyboard as a musical interface due to its availability, affordability and portability advantages over other gestural controllers.
The musicality of typing gestures and sounds has been exploited in pieces such as *The Typewriter* (Anderson, 1953 [2010]) and *The Cave* (Reich and Korot, 1994). However, these pieces present typing gestures within strict, mechanical rhythms, rather than exploring the more natural rhythms that result from the typing of actual text by a reasonably proficient typist (Waite, 2015).

Lee et al (2016) and Lee and Essl (2017) discuss the potential for the writing process itself to be performative. In Lee's work, the temporal separation of writing and reading is eradicated by the real-time projection of typed letters and mapping to audio outputs. In this way, an expressive performance is possible that not only reveals the temporal dynamics of the writing process, but also gives the audience an insight into the writer's cognitive and emotional state. As well as similarities with live coding (Brown and Sorensen, 2009; Collins and McLean, 2014), this practice of *live writing* has parallels with singing, in which communication is possible through how the material is presented as well as what is being presented.

In singer-songwriter performance settings, the lyrics to unfamiliar material may often be obscured by other elements such as the physical presence of the singer and their vocal and instrumental performance (Waite, 2015). Performing lyrics by typing them, presenting the typing gestures as musical and linking text input to generative processes would also serve a

more experimental aesthetic through deterritorialisation[11] of the voice and guitar (Hansen, 2005), while projecting the typed letters in real-time would place the lyrics of the song at the centre of the audience's attention.

The link between writing and music are further explored through the literary connections to the two 'typing' pieces. *Kafka-Esque* uses a translated quotation from Franz Kafka (Goodreads.com, n.d.), while the lyrics for *Leave My Room* are based on a passage from *On the Road* (Kerouac, 1991, p.172-173).

3.4.2. System architecture

3.4.2.1. Overview

An overview of the system architecture used for the 'typing' pieces is shown in Figure 35. The system configuration is similar to the 'explorative-generative' systems in that the performer interacts with the system directly through controllers, performing on these rather than with the system (as in the 'multi-tool' pieces). Typed letters are projected in real-time with accompanying visual effects to support the pieces' themes and narratives. The processing of typing gestures generates melodies and rhythms, with an additional MIDI controller (*Nanokontrol*) used for dynamics and variation through modification of device levels and effects parameters. In *Kafka-Esque*, the video also controls the timbre of some of the synthesiser elements.

The system for *Kafka-Esque* was created solely in Max. *Leave My Room* uses Max for Live devices for audio generation, Processing for the visuals and Max for the text processing (Max

[11] In the context of this enquiry, deterritorialisation refers to the removal of the voice and/or guitar from their position as principle sound sources in popular music (Hansen, 2005).

for Live devices could not be used for text processing as Live's shortcuts cannot be deactivated). Due to some of the text processing for *Leave My Room* being beat-critical, Ableton's (2016) Link is used to maintain synchronisation between Max and Live.

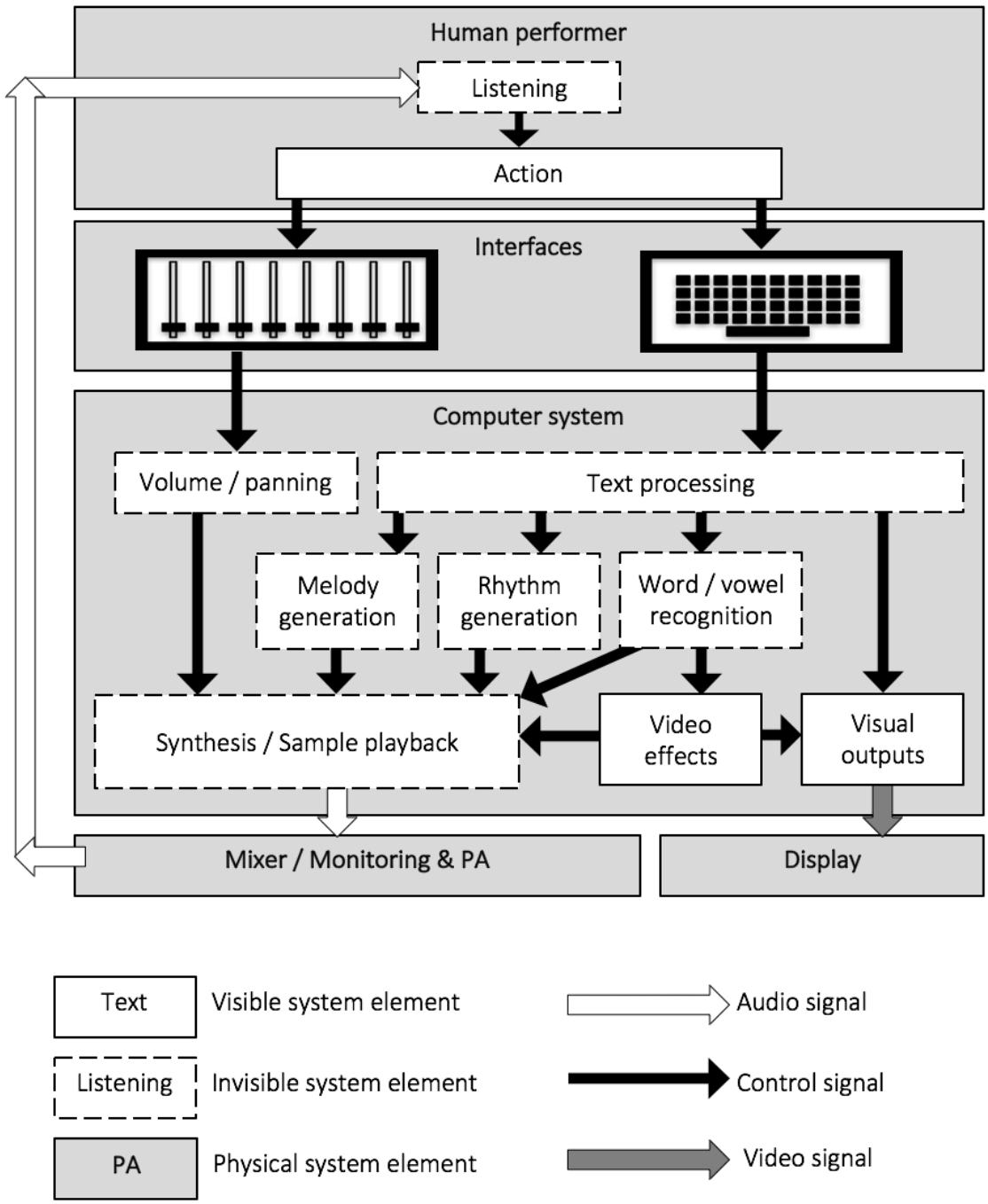

Figure 35: Architecture of typing systems for Kafka-Esque *and* Leave My Room.

3.4.2.2. Rhythmic typing gestures

Two methods are used to capture the rhythm of typing gestures. The same delta time method (Winkler, 2001) used in *Willow* operates alongside a device that records and plays back MIDI notes using two *detonator* objects. Rhythms are cleared, loaded and played back by the performer using bespoke keyboard shortcuts and are linked to samplers containing recordings of typing sounds.

3.4.2.3. Melody generation

Both pieces make use of devices that trigger vowel samples and synthesise vowel sounds when corresponding key combinations are detected. The pitches of these are controlled by an adaptation of Rowe's (1993) real-time version of Guido's system. Additional melodic material is provided by a pre-determined, cyclical note sequences controlling the pitches of synthesiser layers. Presses of the space bar cause the next note in the sequence to be played, meaning that the length of each note is determined partially by the text, partially by natural typing gestures and partially by the performer's feel for where a change should be.

3.4.2.4. Visuals: text display and video effects

In order to support the comparison between typing and singing, the visuals feature the real-time presentation of text as it is typed, letter by letter. A further similarity with singing (as well as a feature that distinguishes the pieces from Lee's live writing) is the inability to alter text once it had been typed, resulting in typographical errors becoming part of the performance. The displayed text is cleared using keyboard shortcuts, representing the disappearance of a sung phrase from the current moment into memory or oblivion. This action is accompanied by a simultaneous burst of audio and video noise. Further visual effects are used to support the themes and narrative of the text. These are unique to each piece and will therefore be discussed in 3.4.3 and 3.4.4.

3.4.3. Kafka-Esque

3.4.3.1. Overview and description

Kafka-Esque uses a quote from Franz Kafka as the 'lyrics' for the piece. As well as being a quote from a writer, the passage portrays the simultaneous withdrawal from and engagement with the world – something that can be achieved through the act of writing and, in the Internet age, through the computer keyboard. Beginning with a solitary, indoor scenario, the narrative of the piece portrays the growing excitement resulting from increasing connection to the world, before reaching a peaceful conclusion. This narrative is supported by the typing sounds becoming layered with percussive sounds from field recordings (2m 34s); the typing actions becoming faster, more complex and more frantic (4m 10s); the stereo width of the piece increasing and the other audio elements increasing in volume and intensity before fading back out. In addition, key words in the text control the visual elements by crossfading between a still image of an empty chair in an empty room and panoramic videos of a landscape, as well as applying various visual effects (e.g. 3m 02s). A plane of the visuals matrix was used to control the timbre of a synthesiser drone, again supporting the narrative through linking the increasingly chaotic behaviour of the visuals to elements of the music.

3.4.3.2. Bespoke system components

Kafka-Esque makes use of automated visual effects in order to allow the performer to concentrate on audio aspects of the performance. Although similar to the score-following techniques for the 'multi-tool' and 'metaphor' systems, a simpler approach was possible due to the higher reliability of detecting typed letters than detecting precise pitch and amplitude values through signal analysis. Max's *match* object was used to link key words in the text to effects such as crossfading, zooming, chroma keying (dude837, 2012a) and fisheye (dude837, 2012b).

The visuals control the timbre of the melodic synthesiser elements by the mapping of values from a plane of the video matrix to the amplitudes of partial frequencies in an *oscbank~* object and phase values for additional *cycle~* objects. Enveloping processes linked to the typing rhythms create rhythmic level variations. These timbral and rhythmic effects can be heard most clearly at the beginning and end of the piece, when only the melodic synthesiser elements are present.

Figure 36: Studio performance of Kafka-Esque*. Still from a video by the author available at: https://www.youtube.com/watch?v=b7BTb9Cu2g8&t=17s*

3.4.3.3. Composition process

Pre-existing text was chosen in order to disrupt the familiar practice of writing the lyrics once the bulk of the music had been composed. The starting point was therefore the Kafka quote and the idea to build an interactive system that would create music and visuals from the typed text.

The system was built entirely in Max to facilitate a more experimental aesthetic than in the 'multi-tool' pieces, by avoiding a clear pulse and tempo. As discussed in 1.1., it is widely held

that composers are influenced by their tools (Prior, 2009). Using beat-based software such as Ableton Live can encourage constant referencing to a tick-based grid, whereas bar and beat cues in Max are absent unless deliberately incorporated.

Visual material to accompany the text was selected that not only reinforced the meaning of the piece, but also had a deeper, more personal connection. Similar to the lyric-writing approach in *Willow*, it was felt that the connection of the performer to the material was important for authentic expression. Permissions were therefore sought to use a photograph (Washington, 2010) and videos (Tomlins, 2014) of local locations created by local artists. In communicating with them from the solitary confinement of a studio to request collaboration, another parallel was drawn with the theme of the work.

Once the system elements had been built, a *Nanokontrol* was used to control the parameters of the audio outputs and mixer functions. Iterative experimentation, improvisation and rehearsal led to a structure that gradually introduces audio elements to support the narrative of the text and facilitate audience understanding of the system.

3.4.3.4. Conclusions

The use of text, typing gestures, generative processes and ambiguous pulse in combination with repetition, melodic motifs, simple harmonies and dynamics yields a satisfying balance of accessibility with complexity and unpredictability in *Kafka-Esque*. The pervasiveness of the compositional themes throughout the system and the compositional process established a deep connection between the performer and the work, resulting in high levels of expressivity during performance. Furthermore, the similarities with the practice of live writing contribute to the foregrounding of the lyrics in performance. Although the piece cannot be described as popular music due to the lack of a clear pulse and the dominance of generative processes, like *Rows, Columns, Collisions* it laid the foundations for further work within the same system approach. The next piece aimed to include original lyrics, a clear pulse, more pre-composed structures and more obvious links between audio elements and the presentation of typed text.

3.4.4. Leave My Room

3.4.4.1. Overview and description

While *Leave My Room* uses the many of the same system components and the same performance approach as *Kafka-Esque*, it represents an attempt to use the 'typing' system approach in a popular music context. This was achieved by transforming key presses into Morse code rhythms to generate highly rhythmic material with a clear pulse. Morse code has been used in popular music such as Rush's *YYZ* (Rush, 1981) as well as avant-garde pieces such as Erik Satie's (1917 [1999]) *Parade* and is highly applicable to audio-visual work due to its existence in both forms.

Figure 37: System visuals for Leave My Room *showing the live text stream, tinting effects and the flashing cursor.*

Whereas *Kafka-Esque* used a pre-existing fragment of text, *Leave My Room* involved writing original lyrics. The themes of writing and exploration were continued through the use of an extract from *On the Road* (Kerouac, 1991 p.172-3) to inspire the lyrics, which depict a personal and perceptual transformation during a journey on foot around an urban area. To support this narrative, the visuals (Figure 37) feature a map that is gradually transformed

through copying, pasting and tinting of sections of the image in response to specific key presses.

3.4.4.2. Bespoke system components

The Morse code rhythm generation works by creating a string of values from the typed letters. This string is then converted into a sequence of MIDI notes, which are sent into Live six at a time, on six separate MIDI channels at one-bar intervals. The MIDI notes trigger MIDI clips containing the appropriate Morse code rhythm (Figure 38). These rhythms trigger playback from a variety of Max for Live devices. Many of these, such as devices for synthesising sung syllables (Figure 39) and playing back voice samples (Figure 40), were adapted from the *Kafka-Esque* software. Bespoke devices include a sine wave generator with a mechanism for creating a 'call and answer' behaviour to simulate a two-way Morse conversation (Figure 41) and an artificial harmonics generator (dude837, 2016) linked to an instance of *Gen_Arp* to add further complexity and unpredictability (Figure 42).

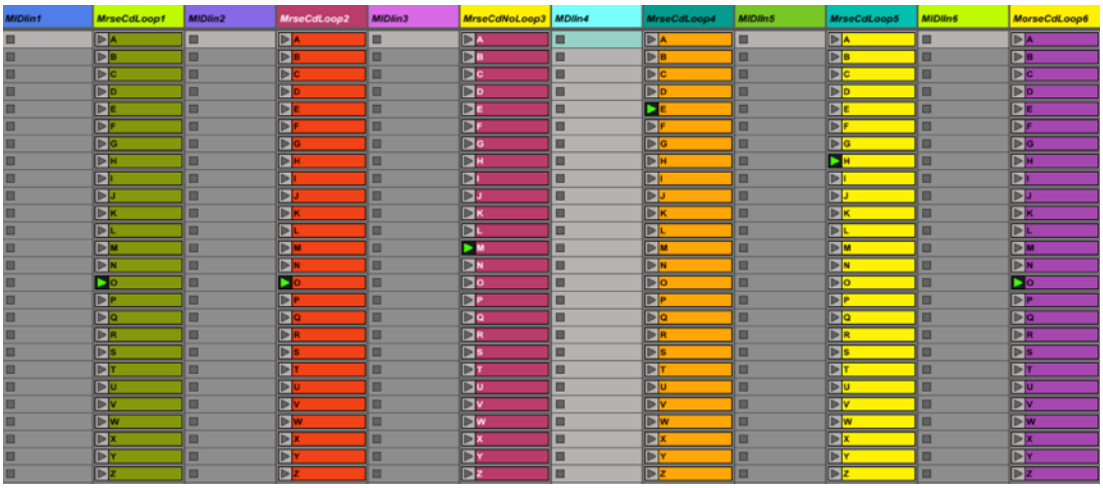

Figure 38: Part of the Live set for Leave My Room *showing the MIDI clips containing Morse code patterns.*

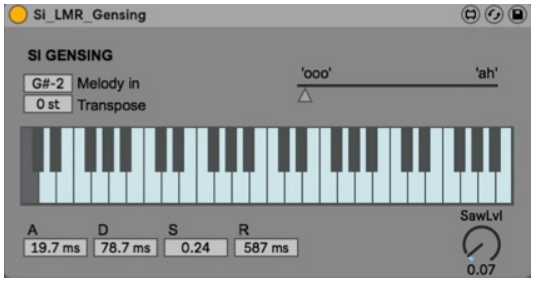

Figure 39: Max for Live Device for vowel synthesis.

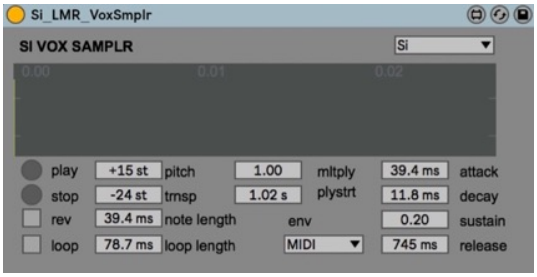

Figure 40: Max for Live Device for playing back sung samples.

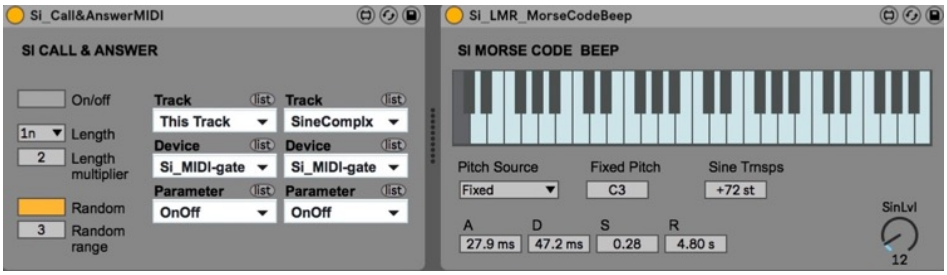

Figure 41: Max for Live devices generating a Morse code sine beep with conversational 'call and answer' mode.

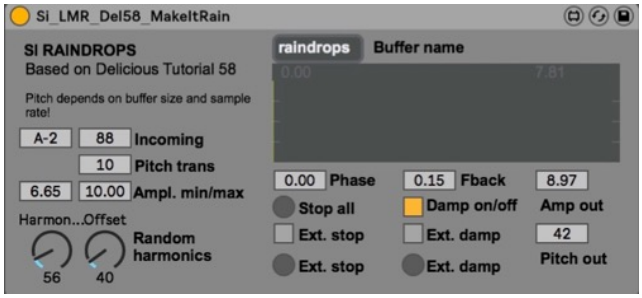

Figure 42: Max for Live Device creating artificial harmonics (dude837, 2016).

The visuals were developed in Processing. Rather than linking the visual effects to a score-following mechanism, particular keys and combinations of keys that repeat throughout the piece cause the starting image to become increasingly scrambled and tinted. For example,

the image becomes scrambled at different scales according to whether a vowel, consonant or the 'Return' key is pressed, while pressing the space bar displays the Morse code pattern for the previously typed letter.[12] As well as displaying the live text stream, audio elements are represented as letters that flash in response to the corresponding Morse pattern. The visuals also feature a flashing cursor, which demonstrates the readiness of the system to respond to performer input.

3.4.4.3. Composition process

An initial sketch of the piece (National Trevor, 2014c) was created entirely within Max using complex text effects linked to audio generators. Following testing with a first draft of the lyrics, the approach was abandoned due to computational efficiency issues and a general dissatisfaction with the resulting music. Following a break in development, further composition work led to the use of Ableton Live to host most of the system devices; extensive incorporation of Morse code processes into the system; reworking the lyrics; the creation of dynamics and sectional boundaries, additional sound generators and a new visuals approach. The use of the map image was suggested by the map-like appearance of the Live set (Figure 38) and the passage from *On the Road*. As in *Willow* and *Kafka-Esque*, choosing to work with a material relating to the local area meant that a deeper personal connection with the work was established. *Mapbox* (2018) was used to create the map image as the starting point for the visuals. Inspired by the fragmented patchwork patterns and colour schemes of Etienne Saint-Amant's (2018) *Memoires* series of artworks, copying and tinting effects were realised in Processing due to the extensive use of *for loops*.

As with *Kafka-Esque*, a *Nanokontrol* was used to control the audio components and mixer functions once the system had been built. Iterative experimentation, improvisation, rehearsal

[12] While not implemented in the portfolio version of *Leave My Room*, this effect can be seen in Figure 29.

and system reconfiguration followed in order to refine the piece. This also involved rewriting the lyrics several times as the arrangement of the piece solidified.

3.4.4.4. Conclusions

While retaining similar system features and audio elements to *Kafka-Esque, Leave My Room* incorporates a more popular music aesthetic, original lyrics and stronger audio-visual relationships. It also serves as a companion piece to *Kafka-Esque* by mirroring its central themes and literary links. Further developments could include more extensive use of Morse code on different timescales; the use of typing gestures to control mixing and device parameters and the use of a video feedback loop to control synthesis timbres (as featured in *Kafka-Esque*). Further use of Morse code rhythms, typing gestures and video feedback could also potentially create more humanised enveloping and pitch control of sample playback.

Although *Leave My Room* incorporates a clear pulse and highly rhythmic elements, any attempt at classification would be likely to locate it in the more experimental regions of electronica. An alternative system approach was therefore developed that sought to build on the successes of the previous three approaches by:

- Enabling the human performer to sing and play guitar.
- Producing music that could be classified as popular music.
- Incorporating significant experimental aspects through high levels of system agency.
- Presenting unifying themes that connect the composition and the system.
- Revealing the operation of the system to the audience.

3.5. ‘Metaphor’ pieces

3.5.1. Introduction and background

Real-world metaphors, particularly those that model physical behaviours, have been used as a design strategy in interactive systems to facilitate both user and audience understanding (Johnston, 2013). Whether grounded in the laws of physics or cultural norms, real-world objects and behaviours represent shared knowledge for composers, performers and audiences (Waite, 2016; Waite, 2017a), and can therefore engage audiences through providing an element of familiarity. This is supported by the extensive use of metaphor as a composition strategy (Emmerson, 2007; Demers, 2010) and that combine experiences from both within and outside of music (Smalley, 1996).

Systems based on analogies and metaphors enable the use of intuitive mappings to connect performer gestures to system sound. For example, Rajmil Fischman’s (2013) *Manual Actions Expressive System* and Imogen Heap’s *Mi.Mu* gloves (Dezeen, 2016) model the manipulation of imaginary materials through gestures such as striking, stirring, lifting and placing. Dahl and Wang (2010) make use of a throwing and catching metaphor; Johnston et al (2009) use a spring and mass system while Johnston (2013) uses a particle system as a performer interface. Furthermore, the relationship of metaphor-based systems to shared understanding lead to intuitive links for mapping to audio and visual outputs.

A further advantage of modelling real-world behaviours is that they can be highly complex and unpredictable, leading to interesting musical results connected to deeper truths about the world (Xenakis, 1992). Interactions with chaotic systems such as springs, particles and pendulums can be recreated in software using well-resourced tools such as Cycling ‘74’s *jit.phys* Max objects (Ramirez, 2012) and Processing (Shiffman, 2012).

3.5.2. System architecture

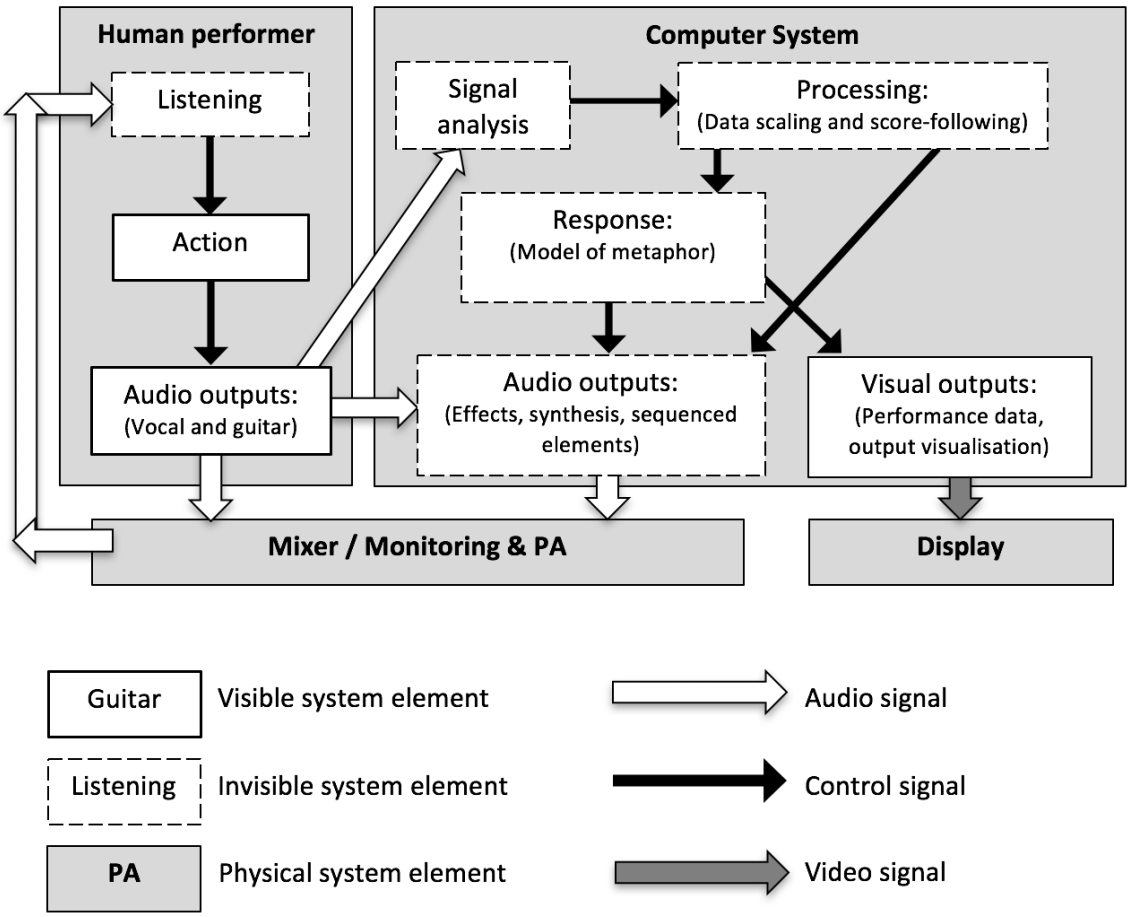

Figure 43: System architecture for real-world metaphor systems.

Although both approaches use live audio input data and score-following, the key difference between the architecture of the 'real-world metaphor' and 'multi-tool' systems is the use of a single metaphor in place of multiple response algorithms, as shown in Figure 43. Complexity is achieved through connecting the behaviours of a central software model to multiple audio output devices.

3.5.3. Church Belles

3.5.3.1. Overview and description

Church Belles, the first of the 'metaphor' pieces, models an array of ten church bells in Max using *jit.phys* objects (Figure 44). Church bells were selected as they are a highly familiar cultural object with a simple physical mechanism, capable of producing complex timbres and unpredictable rhythms. The themes of the piece reflect the contrasting peacetime and wartime connotations of church bells through the relationship and personal struggles of a serving RAF navigator and his wife during the Second World War.

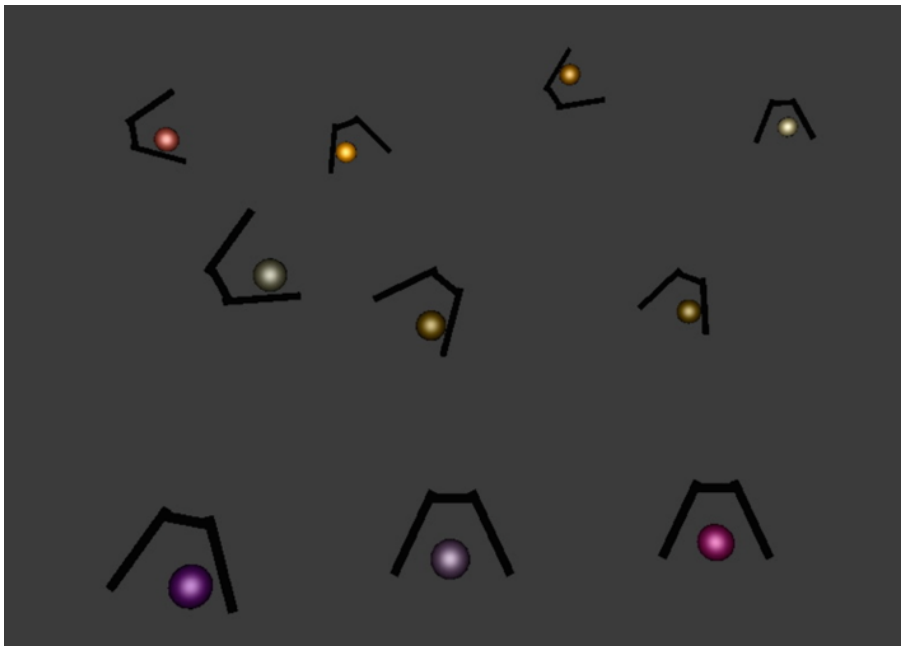

Figure 44: System visuals for Church Belles*. Bell size and position relates to its pitch, with the lowest being the biggest and at the bottom left of the screen. Taken from video by the author (National Trevor, 2016).*

Similar to the use of a rope to ring actual church bells by rotating them about a hinge, the virtual bells are 'rung' by mapping the velocity of specific guitar notes to a rotational force applied to the hinge of the corresponding bell. Each bell consists of a hinged 'clapper' that, on striking the body of the bell, causes the bell to sound by triggering a bank of synthesisers and samplers. To create a backing vocal layer, the sung vocal part is pitch-shifted according to the pitch of the sounding bell.

In the second section of the piece (3m 24s), a change in the guitar part is detected by a score-follower which modifies the behaviour of the system and its audio outputs. Constraints on the bells' hinges are removed, allowing the bells to rotate through 360°. As well as producing bell-like sounds, they also trigger a synthesiser designed to resemble an air raid siren. If the velocity of the guitar note mapped to the ringing of a particular bell exceeds a threshold, the bell detaches from its hinge (Figure 45). Collisions with the boundaries of the virtual space trigger playback of voice recordings made during Second World War (BBC Learning, 2015).

Figure 45: System visuals for Church Belles *during the second section of the piece showing bells rotating through 360° and detaching from their hinges in response to velocity thresholds being exceeded by incoming guitar notes.*

In the final section of the piece (5m 20s), the score-follower detects the return to the original guitar part, restoring the original functioning of the system and audio output. At the end of the piece, the bells fall from their hinges in response to a trigger melody played on the guitar.

3.5.3.2. Bespoke system components

The main Max for Live device for the piece (Figures 46 and 47) handles the modelling of the bells; the creation of MIDI notes; score-following and mapping guitar notes to the 'ringing' action to specific bells. Each bell is configurable in terms of size, colour, position, strength of ringing action and collision strength. Variety in the bells' tones is achieved by separating the initial strikes caused by the linked guitar note from subsequent strikes caused by the inertia of the bells. The resulting MIDI notes are sent to separate banks of samplers and synthesisers to create the bell sounds.

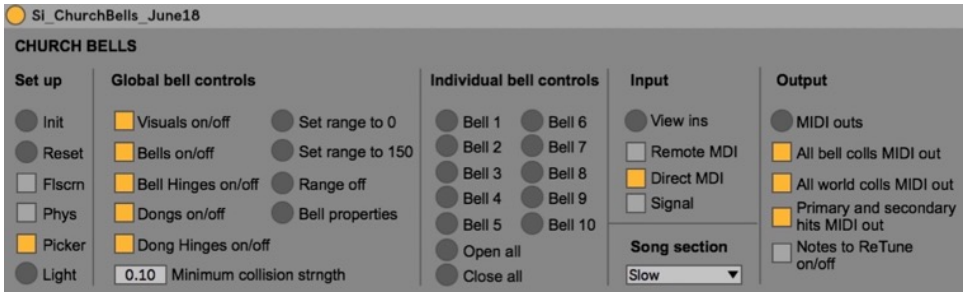

Figure 46: Part of the main Max for Live device for Church Belles *showing setup, global, individual bell and MIDI output controls.*

Figure 48 shows the section of the main Max for Live device dealing with the mapping of incoming guitar notes to the 'ringing' of each bell. A one-to-one mapping strategy is used for the lower pitches (bells 5-8) to support a clear tonal centre and clarity in the low frequency spectrum. A one-to-many strategy is used for the higher bells (bells 1-4) to generate a more textural effect in the higher frequencies.

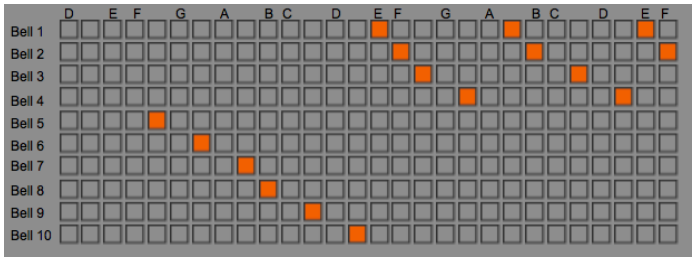

Figure 47: Part of the main Max for Live device showing the mapping of detected guitar notes to the bells.

Backing vocal layers are created by pitch-shifting the live vocal to the most recently sounded bell via a device using the *retune*~ object (Figure 48). A further layer is generated in the second section of the piece by linking the bass note of the guitar to a bass synthesiser. The bass synth could reliably be triggered simultaneously with chord changes due to the bass note on the guitar being played ahead of the bar.

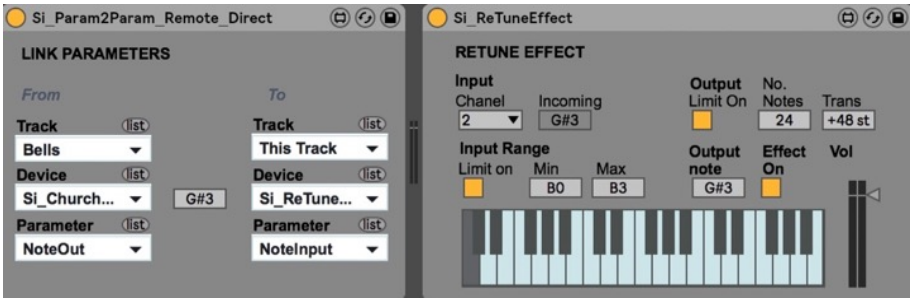

Figure 48: Retune effect linked to the bells device pitch-shifting the live vocal to create backing vocal layers.

3.5.3.3. Composition process

Church Belles was written in tandem with system development. The first stage in the composition process involved modelling a church bell in software. This was then expanded into an array of ten bells based on the tunings of the bells of the Notre Dame cathedral in Paris (notredamedeparis.fr, n.d.). Inspired by the music composed for the 850th anniversary celebrations of the cathedral (DeZigeunerbaron, 2013), improvisation with the system using a MIDI keyboard set the piece's tempo and mood before further improvisation with voice and guitar generated the guitar part and vocal melodies for the opening section. Additional system configuration then followed, including finalising the guitar-bell mappings, adding the Retune effect and quantising the MIDI output from the bells at 16th note level (nonagon, 2010) to improve rhythmic coherence with the guitar part whilst preserving synchronisation with the visuals.

Additional exploration of the system led to the idea of exploiting the digital nature of the system to allow radical changes in system behaviour. Limits were removed from hinges to allow full 360^{o} rotation and hinges were deactivated to allow bells to 'fly' around the virtual

space. Further improvisation with the system in this mode led to the development of guitar and vocal melodies for the second part of the piece. The contrasts between the two sections inspired the peace-war theme of the lyrics, which in turn led to the inclusion of air-raid sirens and samples of Second World War recordings. Finally, reviewing a previous version (National Trevor, 2016) led to the addition of a bass part to the second section of the piece to add weight and contrast.

3.5.3.4. Conclusions

Overall, *Church Belles* was highly successful due to its minimal use of sequenced material and the balance of unpredictable, complex audio output with harmonic and rhythmic coherence. The use of dynamic system behaviour was a particular strength as this led to unforeseen compositional developments that brought additional variety and depth to the song. In terms of the goals identified in 3.4.4.4, a piece of popular music involving vocals and guitar was created using a system that demonstrated significant memetic and performative agency. This resulted in strong thematic connections and high levels of coherence between the human, system and visual elements. The use of a physical model with strong cultural associations assisted in revealing the system to the audience.

Further system adaptations could be made for future compositions. These could include the ability to dynamically alter the pitches and vertical locations of the bells and the development of the system's audio outputs to facilitate a deeper exploration of timbral characteristics of church bells, such as harmonic complexity, rhythmic phasing effects and implied fundamentals (Hibbert, 2008). Causal links between specific guitar notes and bells could be clarified to the audience through representation of the guitar in the system visuals.

3.5.4. Broken Starling

3.5.4.1. Overview and description

In direct contrast to *Church Belles*, *Broken Starling* involved creating an interactive system for the performance of a composition that had already been fully realised as a recording. The starting point of the original composition was a recording of a washing machine on a fast spin cycle, which produced a constantly evolving yet infectious rhythm. This became a metaphor for the themes of family life and fatherhood. Other found sound materials were incorporated from domestic life such as bleeding radiator pipes and children playing with toys. Around this were woven additional percussive, melodic and vocal elements to create the finished track (National Trevor, 2013).

Figure 49: System visuals for Broken Starling *showing the three coloured balls that collide with the washing machine's drum and ridges to recreate the found sound rhythm.*

The approach to creating a live version of the piece was inspired by performances of George Antheil's (2001) *Ballet Mécanique*, which featured of the use of actual aeroplane engines onstage (Chadabe, 1997). A virtual washing machine was created as a Max for Live device,

again using *jit.phys* objects to enable the reconstruction of the source for the original recording (Figure 49). The constantly changing rhythms are generated by collisions between the washing machine's rotating drum/ridges and the balls bouncing around within them. Further variation is created by changing the number of balls and adjusting the speeds of the drum and ridge rotations. Other elements in the visuals display the incoming guitar pitch (coloured dial) and pre-sequenced drum hits (monochrome dial and lights).

The live version of the piece includes many of the same elements and an identical overall structure to the original. It relies heavily on pre-sequenced material and pre-configured effects taken from the original recording. These are controlled by a score-follower, which is in turn controlled by a live guitar playing the original bassline. Indeterminacy is increased through the use of looping devices controlled by the collisions in the physical model and using the guitar audio as their input. The use of the original bassline as pre-sequenced material in the final sections of the piece enables the performer to stop playing the pre-composed bassline and improvise with the loopers.

3.5.4.2. Bespoke system components

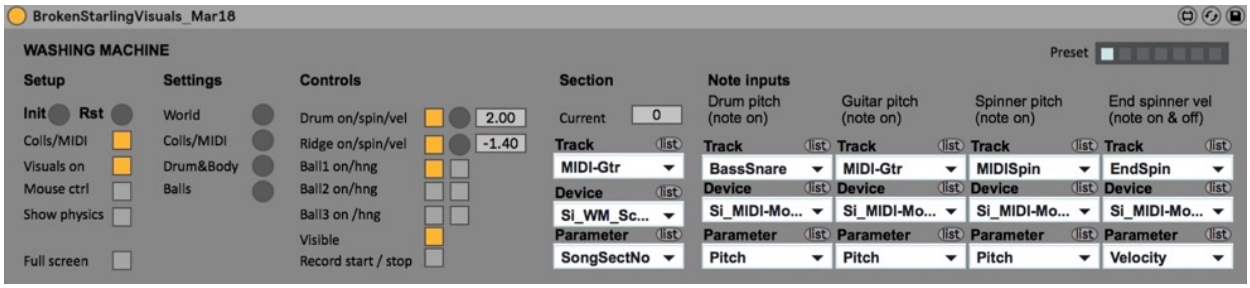

Figure 50: Device generating the physical model with its behaviour linked to the score-follower and sequenced material.

As with *Church Belles*, a single Max for Live device generates the physical metaphor and system visuals (Figure 50). The washing machine model involves two rotating elements whose speeds could be independently set: the main drum and the set of three ridges. Between one and three balls could be activated and produce MIDI notes by colliding with the drum, the ridges and each other. These MIDI notes were quantised at high resolution to

preserve rhythmic coherence (nonagon, 2010) and sent to a sampler containing washing machine impact sounds.

Figure 51: Dynamic delay on the live vocal. A thresholding mechanism activates the playback of buffer contents during breaks in the vocal phrases.

In the original version, the last word of each vocal phrase had a stereo echo effect applied. This was recreated as a Max for Live device that used live recording and thresholding to achieve a similar result in real-time (Figure 51).

To introduce more indeterminacy to the live version and further distinguish it from the original, a bank of loopers operating on the guitar part were created and their behaviours linked to the score-follower and events in the physical model (Figure 52). The loopers enable the performer to generate interesting material from a simple, improvised guitar part.

Figure 52: Looper on the guitar track controlled by the physical model. Collisions between balls and drum were linked to the playback position and speed of recordings of the live guitar part.

3.5.4.3. Composition process

The first step was to program the physical model to recreate the rhythmic behaviour of the original found sound object. The note events produced by the model were linked to a sampler containing recordings of washing machine drum impacts, which had been recorded specifically for the live version. The visuals design was taken from the washing machines in the launderette where several of the original found sound recordings were made.

Following the creation of the physical model, two key decisions were required relating to the amount of pre-sequenced material to be used and how to interact with the system. Due to the limited scope of the physical model and the need to retain key features of the original song, significant amounts of pre-sequenced material from the recorded version would be used. Rather than use additional controllers to control playback, it was decided that the bassline would be played on guitar. The presence of melodic motifs in the original bassline would serve as triggers for the score-follower which would control playback of the pre-sequenced material. To allow more flexibility in terms of when sectional changes took place, the pre-sequenced material was either looped in its entirety or over the last few beats of the phrase.

In later sections of the track, the original, pre-sequenced bassline is used, creating space for an additional guitar layer (2m 45s). Rather than compose and rehearse a new guitar line, a simple, semi-improvised guitar provides audio input for the bank of loopers connected to the physical model. As well as foregrounding system elements, this enables the performer to concentrate on the vocals and interactions with the system.

3.5.4.4. Conclusions

Broken Starling demonstrates the use of a 'metaphor' interactive system to create a new, live version of a pre-composed piece by modelling the source of the original found sound recording sonically, visually and behaviourally and by transferring the main instrumental

melodic element to a guitar part. This resulted in a reduced reliance on pre-sequenced material; lower demands on the human performer through the use of a familiar singer-songwriter performance paradigm; the generation of unique elements through live looping and reliable score-following. As well as controlling playback of sequenced material and activation of audio effects, the score-follower also enables the dynamic behaviour of the physical model (varying the number of balls and drum rotation speed) to support the narrative of the piece.

However, the reliance on significant amounts of pre-sequenced material and the use of additional devices outside of the main metaphor in an attempt to recreate an existing composition repeat many of the shortcomings of the multi-tool approach. The next piece sought to implement a system for an existing piece of music where a single audio-visual metaphor would be able to control all aspects of the system's behaviour, with minimal reliance on pre-sequenced material.

3.5.5. Piece for Tape

3.5.5.1. Overview and description

Piece for Tape involved developing a system for a partially-written song. While the main guitar riffs and vocal melodies already existed, the arrangement and lyrics were yet to be created. Rather than using physical modelling, cassette images were chosen to represent the behaviour of looping and granular synthesis tools that would generate accompaniment layers from the live guitar and vocal. Cassettes are well-known cultural objects whose functioning can be assumed to be widely understood and therefore provide a point of shared understanding. Their functioning and status as aesthetic objects of nostalgia (Schrey, 2014; Hix, 2015) connect to the song's themes of imperfect memory and the non-linearity of existence. Further inspiration was taken from the use of tapes to explore similar ideas in Kagel's (1958 [2004]) *Transición II* (Sanden, 2013).

The piece begins with a drum loop comprising recordings of personally-owned vintage cassette deck mechanisms. As the drum loop fades in, the corresponding cassette tape (bottom centre of Figure 53) grows in size. As the live guitar part begins, two more cassettes appear representing the recording and playback of the live guitar part (far left and right of the middle row). The starting and stopping of the cassettes are accompanied by percussive samples of tape deck mechanisms which contribute further rhythmic complexity to the drum loop. As the vocal part begins, two more cassettes appear to record and playback the live vocal (centre left and right of central row). As the piece progresses, more tapes are added representing granular synthesis layers (top row, 1m 55s) and further recording and playback of the guitar (bottom corners, 2m 15s). At the end of the piece, the audio elements and corresponding cassette images fade away layer by layer.

Figure 53: System visuals for Piece for Tape. *The cassettes are arranged by instrument grouping and position in the stereo field. Taken from video by the author (National Trevor, 2017)*

To strengthen thematic links between the song and the system, the tape images used are of blank cassettes or aging cassettes that have had their recording protection holes taped over. The label on each tape contains handwritten excerpts of lyrics from the piece. To facilitate

system transparency, the cassettes are arranged by instrument group and position in the stereo field and flash when the corresponding looper device is recording.

3.5.5.2. Bespoke system components

Each cassette in the visuals is either a looping device (Figure 54) on the live guitar or vocal track, or a granular synthesiser device (Henke, 2013; IRCAM, 2015) that uses one of the looper's buffer contents as its source file.

The playback, stopping and recording messages to each looper triggers the playback of percussive recordings of cassette decks stored in a sampler instrument which add interest and variation to the drum loop. As in *Church Belles* and *Broken Starling,* these were quantised (nonagon, 2010) to preserve rhythmic coherence. However, offsets in the recordings were maintained to create a looser feel.

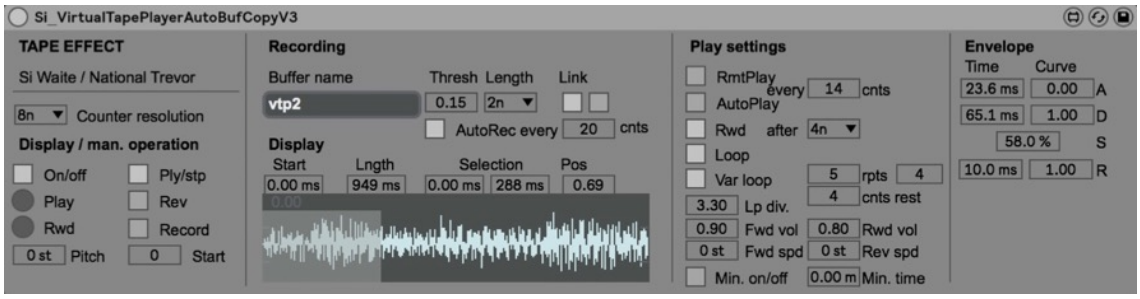

Figure 54: Looping device used to generate additional layers from the guitar and vocal input. Four of these are used on the guitar and two on the vocal.

3.5.5.3. Composition process

Having created a partially-written song comprising guitar parts and vocal melodies for verse and chorus sections, the system-building began with the creation of a visual representation of a cassette tape and the linking of its behaviour to a looping device. The complexity of the system's audio and visual output was increased by using several instances of the same device with different recording and playback settings and three granular synthesis devices. A score-

follower was then created to detect the different sections and chord changes in order to vary the behaviour of the loopers and granular synthesisers throughout the piece. Experimentation with the system led to the development of an instrumental bridge section and improvisation sections after the first chorus and at the end of the piece, where the live guitar playing moves to a higher register and becomes more sporadic, allowing the audio output of the system to be foregrounded.

3.5.5.4. Conclusions

The interactive system for *Piece for Tape* generates unpredictable, constantly evolving accompaniment layers that are highly responsive to performer input. The use of reflexive approaches, flexible score-following, percussive sounds linked to the software functioning and minimal sequenced material results in a highly expressive piece that differs significantly on each rendition. Unlike the other pieces in the portfolio, the central metaphor is used for all of the audio and visual elements. Furthermore, the strong cultural associations of the cassette potentially provide a more fertile common ground between songwriter and audience than what can be provided by a purely physical or technical understanding. This may serve to invite audiences into the wider themes of the song as well revealing sound production processes.

Although *Piece for Tape* was felt to be a successful, fully-realised composition, further system developments could incorporate the incremental degradation of the looped recordings as in William Basinski's (2001 [2012]) *Disintegration Loops*, though over much shorter timescales.

4. How does the use of interactive systems impact on the songwriting process?

In responding to the first research question, section 4.1 will establish that aspects of system-building can be considered to be compositional, before discussing the impact of system-building on the overall songwriting process in 4.2. This will be followed by reflections derived from introducing interactive systems at specific songwriting stages in 4.3. Strategies for achieving coherence between the indeterminate audio output of interactive systems and the composed features of popular song will then be detailed in 4.4. Finally, section 4.5 will suggest strategies for combining human instrumental/vocal output with system electronic output to create a cohesive perceptual whole.

4.1. System-building as composition

4.1.1. System-building as composition vs. system-building as creating tools

Composers creating systems for their own use within the context of a single composition can be contrasted with creating tools for use by others across multiple compositions. For example, system-building and composition took place simultaneously in *Church Belles*, while the sequencer created for the 'explorative-generative' pieces was intended to be a tool for more general use. This resulted in a large range of features being created before any composition took place, many which remained unused. This contrast can also be seen in the impact of the systems on the final pieces. The complex themes of *Church Belles* were both a result of the system and a stimulus for its continued development, meaning that most of the

system features were used in the piece. In the 'explorative-generative' pieces however, *Rows, Columns, Collisions* is a study that partially explores the system, while much of the creative development for *I Begin Where You End* was done outside of the system using standard, linear techniques. Furthermore, when creating the sequencing tool, considering future compositions and other users resulted in a significant amount of time being spent on designing user interfaces and adding features that were not used in the compositions.

The recycling or repurposing of elements within modular systems suggests that the contrast between composition and tool creation can be seen as a continuum. In the pieces using the 'multi-tool' approach, several Max for Live devices were incorporated into a modular system as suggested by the unfolding composition. Some of these devices were developed during the composition process (such as the loopers in *Willow*) whereas others were pre-existing tools (e.g. *Gen_Arp*). The compositional aspects of working with pre-existing devices depended on the extent to which they were adapted or configured to work within the context of a song. For example, the loopers in *Willow* were reused but significantly adapted in each of the 'multi-tool' and 'metaphor' pieces, with unique functionality to suit each piece's compositional aims. This is further illustrated by the 'typing' pieces. While the development of a bespoke system for *Kafka-Esque* involved a tight coupling of system-building and composition, *Leave My Room* re-used many of the same devices. However, the addition of Morse code generation to the text-processing devices restored a significant compositional aspect.

The pieces created with the 'metaphor' system approach were unique in that each piece required the creation of a central device to represent the metaphor and link to the other aspects of the system. Where the programming took place earlier in the composition process (*Church Belles* and *Piece for Tape*), there was significant, mutual memetic agency between piece and system - suggesting that system-building was highly compositional. In *Broken Starling*, where the system was created following composition, the memetic agency was mostly one-way. However, the system still influenced the live version through the generative rhythms created by the physical model and the use of loopers on the guitar channel.

Figure 55: Possible dimensions for programming as composition vs programming as tool development. The approximate position of the principal devices created in each of the pieces along each dimension is represented by a coloured dot.

Figure 55 shows possible dimensions for locating the programming of specific device on the composition-tool development continuum as evidenced by the pieces in the portfolio. Whilst these dimensions are not completely independent, the location of devices created for each piece strongly suggest that system-building can be more closely integrated into the songwriting process by:

- Aiming to create bespoke systems and devices for each piece rather than tools for use in multiple pieces.
- Alternating between programming and composing from the beginning of the songwriting process to increase the system's agency over the piece.
- Remaining unconcerned with developing a tool for multiple users.

- Establishing a unity between the system and the compositional themes so that the system is about the piece and the piece is about the system.
- Prioritising the creation of features for immediate use at the current point in the songwriting process.

4.1.2. Composing behaviours vs. composing material

As established by Maeda (2004) and Ribas (2014), the ability to program software allows for the incorporation of real-time, indeterminate processes into artistic practice. An interactive system can therefore provide a songwriter with a composition and performance partner whose range of possible behaviours is configurable to the composition but whose exact output will vary. Similar to instructing a human partner to improvise within the framework of a song, the songwriter must program the system with knowledge of the score and define the range of possible behaviours at key points. As detailed in 3.3.1.3, score-following devices were created for each of the 'multi-tool' and 'metaphor' pieces that enabled system behaviour to change as the song progresses. This serves to maintain harmonic and rhythmic coherence between the indeterminate system audio output and the composed song elements, while enhancing the expressiveness of the score. For example, in *Unquiet*, the score-follower alters *Gen_Arp* parameters to vary the length and speed of the arpeggio between verses, choruses and other sections in the song. This process of composing behaviours (Di Scipio, 2003) is also evident in *Church Belles* and *Piece for Tape*. In the former, the switching of the bells' movement from swinging to rotating (3m 26s) marks a fundamental shift in system behaviour. In *Piece for Tape*, the gradual addition of loopers and granular synthesisers increases the complexity of the system as the song progresses.

Working with real-time software processes can result in emergent behaviours producing material that would be very difficult to imagine or create using more standard, non-real-time composition techniques. Examples include the complex, evolving rhythmic patterns in *Rows, Columns, Collisions*; the melodies of the backing vocal layers in *Church Belles*; the stuttered,

pitch-shifted guitar melodies produced by the loopers in *Broken Starling* (2m 46s) and the electronic vocal layers in *Brains Need Bodies Too*.

4.1.3. Stages of composing in system-building: construction and configuration

The development process of the systems in the portfolio suggests two stages of system-building: 'system construction' and 'system configuration'. Table 1 summarises construction and configuration activities that contributed to the composition of each piece.

System construction involves designing, prototyping, testing and refining to establish a reliable system that exhibits a range of artistically interesting behaviours, for example the creation of the sequencer device for the 'explorative-generative pieces' and the physical model for *Church Belles*. System configuration involves further programming to impose limits on the compositional algorithm's range(s) of behaviours through mappings to inputs, processing and internal parameters as well as mapping their behaviours to audio outputs.

Throughout the development of the portfolio, systems were characterised by the increasing use of separate Max for Live Devices for constructing the main system elements (input, processing, response and output) and configuration devices modifying their behaviour through compositional decisions implemented in code. For example, *Brains Need Bodies Too* involved constructing separate devices for detecting guitar notes (input), score-following (processing), melodic generation (composition algorithm) and synthesis (output). Separate configuration devices were then created to create mappings between these system elements. As well as maintaining conceptual clarity, this modular approach was advantageous to the creative workflow in terms of facilitating the reusability of devices and keeping track of improvements.

System Type	Piece	System construction	System configuration
Explorative-generative	*Rows, Columns, Collisions*	Creation of multi-dimensional sequencer	Internal modulation (e.g. columns control row speeds) Mapping to outputs (synths and samples)
	I Begin Where You End	Adaptation of multi-dimensional sequencer	Mapping to outputs (synths and samples)
Multi-tool	*Willow*	Creation of looping effects Adaptation of spectral effect Adaptation of granular effect Adaptation and creation of rhythm generators	Setting constraints on looper behaviour Mapping effect parameters to inputs and score-follower Mapping to outputs (samples)
	Unquiet	Adaptation of looping effects Adaptation of arpeggiator	Mapping effect parameters to inputs and score-follower Mapping to outputs (synths and samples)
	Brains Need Bodies Too	Adaptation of looping effects Creation of noise generators Creation of AI melody generators	Mapping effect parameters to inputs and score-follower Mapping to outputs (synths and samples)
Typing	*Kafka-Esque*	Adaptation/creation of rhythm generators Adaptation/creation of melody generators Adaptation/creation of effects	Internal modulation (visuals and synth timbres) Mapping to outputs (synths and samples)
	Leave My Room	Creation of text-Morse code generators	Mapping to outputs (synths and samples)
Metaphor	*Church Belles*	Modelling of church bells Extending of model Creation of pitch-shifting effects	Mapping guitar notes to bells Mapping bells to synths and samples Mapping bells to vocal pitch-shifting Mapping score-follower to model behaviour and effects parameters
	Broken Starling	Modelling of washing machine Adaptation of looping effects	Mapping physical model to looping effects and sample output Mapping score-follower to model behaviour and effects parameters
	Piece for Tape	Creation of looping effects Adaptation of granular effects	Mapping score-follower to system behaviour and effects parameters

Table 1: Programming stages for devices created for the pieces in the portfolio.

Having established that the concept of play is important in composition, and that aspects of programming can be seen as composition, it follows that play is also important in system-building. This can occur through direct manipulation of a system's overall capabilities during the construction stage or through experimenting with mappings during configuration. Furthermore, these two stages may well be iterative. For example, *Church Belles* involved first constructing the system of virtual bells before configuring the system to respond to guitar input. The direct manipulation of the system (rather than improvisation via the guitar)

to explore the system's capabilities (deactivating bell hinges and using the mouse to 'throw' the bells around the virtual space) led to the idea of creating a new section of the piece in which the behaviour of the bells radically altered. This directly led to the creation of a score-follower. Further play with a Max's *retune~* object led to more construction followed by configuration to implement a vocoding effect on the sung vocal part.

4.1.4. Non-compositional aspects of system-building

Having explored how specific aspects of system-building can be seen as composition, it is worth mentioning aspects that, while necessary, were not considered as part of the songwriting process. As suggested by Winkler (2001), some system components will be functional rather than compositional and can therefore be re-used between systems. This was certainly the case with input and processing devices, which were re-used across the 'multi-tool' and 'metaphor' pieces. These devices included processes such as:

- Level analysis of the instrumental/vocal audio signals.
- Melodic and harmonic analysis of incoming guitar pitches.
- Monitoring current song position.
- Automatic recording of audio signals and representational data.

Although the systems in this portfolio all have a visual element, the potential for the pieces to exist as audio-only versions means that the creation of the visuals was considered as being external to the main songwriting process. While the use of Max's *jit.phys* objects for the physical modelling in *Church Belles* and *Broken Starling* removed the separation between visuals and musical processes, additional visual design work (e.g. colour schemes, use of images) did not impact on the songwriting. The other pieces all used visuals to represent musical processes that had already been programmed and/or to communicate themes that had already been established.

A further aspect of system-building that was separate from the songwriting process was the creation of user interfaces for the system devices. Although 4.1.1 highlights the reduced need to create interfaces for future users, a reasonably well-designed interface assists the composer's creative flow by providing clues to the workings of a devices work following a break in use; makes troubleshooting much easier and facilitates the mapping of device parameters. Working with Max for Live facilitates this by encouraging a modular approach, providing a wide range of user interface objects and limiting the available screen space. Including visual feedback objects in the system interface was found to be especially useful when debugging and mapping, for example through being able to see the behaviour of envelopes in looping devices.

4.1.5. Summary

The findings of section 4.1, relating to the extent to which system-building can be seen as composition, can be summarised as follows:

- While system-building can be seen as an integral part of the composition process, there is a continuum between creating tools for multiple pieces and users and purely compositional activity.
- When working with interactive systems, compositional activity includes composing behaviours and interactions as well as composing material.
- Compositional system-building takes place over two stages: first creating the individual components and secondly configuring their behaviours.
- Important but non-compositional aspects of system-building include creating visuals and developing user interfaces.

These points will be reiterated and further discussed in 6.1.1.1.

4.2. Impact on the overall songwriting process

4.2.1. Overview

In order to assess the impact of using interactive systems on the process outlined in 4.1.2, their use at each stage of the songwriting process will be discussed. Table 2 provides an overview of the portfolio that shows the stages of the songwriting process in which systems were implemented and which pieces included composition techniques external to the system.

The remainder of 4.2. will discuss the three songs that involved the use of an interactive system at all stages of the process (*Rows, Columns, Collisions* is excluded as it not considered to be a song). The impact of implementing interactive systems at specific stages will be discussed in 4.3.

System type	Piece	Initial song creation	Creating the arrangement	Recording and performance	Composition outside system
Explorative-generative	*Rows, Columns, Collisions*	✓	✓	✓	×
	I Begin Where You End	✓	×	✓	✓
Multi-tool	*Willow*	✓	✓	✓	×
	Unquiet	×	✓	✓	✓
	Brains Need Bodies Too	×	✓	✓	✓
Typing	*Kafka-Esque*	×	✓	✓	✓
	Leave My Room	✓	✓	✓	×
Metaphor	*Church Belles*	✓	✓	✓	×
	Broken Starling	×	×	✓	✓
	Piece for Tape	×	✓	✓	✓

Table 2: Stage of the songwriting process in which the interactive systems were used and whether composition also took place without the system.

4.2.2. Impact of interactive systems on initial song creation

Initial song ideas for several of the pieces in the portfolio came from first creating an interactive system based around a particular concept and then improvising with it to generate musical ideas. In the case of *Willow*, improvisation with the system resulted in a guitar part with eight-bar phrase lengths, a static harmony and varying bass notes (as described in 3.3.3.3). The eight-bar pattern length dictated the phrasing of the vocal melody when transitioning between verse and chorus that would not have been chosen had the system not been in place. As detailed in 3.3.3.1, changes in the guitar part were restricted to those that could easily be detected by the system's score-follower. These included an increase in playing volume for the chorus and a bass note run followed by a radical harmonic shift for the bridge section.

The decision to use typing and Morse code as the basis for the system in *Leave My Room* immediately established rhythmic structures and timbral elements (sine beeps, vocal samples and typing sounds) for the piece. The system themes of typing and communication across large distances informed the choice of a passage from *On the Road* (Kerouac, 1991) as the inspiration for the lyrics, which in turn shaped the overall structure of the composition.

The composition of *Church Belles* began with the modelling of a bell in software. Further research into church bells resulted in the system's extension into an array of ten bells and set the tuning system. Testing with a MIDI keyboard established the initial composition parameters such as tempo and mood, while improvisation with guitar and vocals led to the development of the guitar part and vocal melody for the first section of the piece. The second section of the piece was composed by direct experimentation with the system as detailed in 3.5.3.3. This was followed by further improvisation with guitar and vocal resulting in new guitar parts and vocal melodies. Influenced by the dual functioning of the system, lyrics were then written that explored the contrast between peacetime and wartime use of church bells.

4.2.3. Impact on creating the arrangement

The systems were also used to embellish and refine existing material at the arrangement stage. New system elements were constructed to generate accompaniment layers that contributed additional compositional detail and expressivity. *Willow* involved constructing additional textural, rhythmic and melodic devices linked to instrumental audio and representational input. In *Leave My Room*, new devices were constructed to extend the timbres of the existing typing and Morse code devices. *Church Belles* involved the extension of the system to include vocoding devices, additional synthesisers and samplers controlled by the physical model.

As well as construction activities, system configuration to modify device behaviours was a significant part of the arrangement stage. Much of this took place through linking device behaviours to instrumental/vocal input, a score-follower or MIDI controllers to facilitate expression and maintain coherence across the different sections of the pieces. In *Willow*, spectral effects were activated by the guitar signal while the score-follower allowed variation in the behaviour of the rhythm generators, loopers and granular synthesisers. In *Leave My Room*, the *Nanokontrol* was used to control volumes and effects parameters of system elements to emphasise the narrative of the lyrics. In *Church Belles*, guitar-to-bell mappings were modified to increase expressivity (through using detected guitar note velocity), clarity (through one-one mappings for lower bells) and complexity (one-many mappings for higher bells).

4.2.4. Impact on recording and performance

Recording and performance influenced the final outcome of all three pieces. Particularly when the songwriter is singing and playing guitar, recording is essential to create a break from the simultaneous activities of performing, programming and producing in order to devote attention to listening and reflection. In the case of *Willow*, listening back to recordings

informed production decisions such as drum timbres and synthesiser settings. In *Leave My Room*, reviewing sketch recordings led to most of the initial programming and compositional work being abandoned. Less drastically, listening back to recordings of *Church Belles* led to the inclusion of a bass part and additional drum sounds in the second section of the piece.

Performing, whether in a concert situation or rehearsal, also informed the development of the pieces. This was particularly the case with the more experimental songs such as *Leave My Room,* in which the lyrics were redrafted several times over multiple rehearsals in order to achieve an appropriate length and establish dynamics for the piece. As well as these artistic considerations, extensive rehearsal was also essential on a more technical level to ensure that the devices and their configurations were working effectively. This was particularly true when ensuring the robustness of the score-followers in *Willow* and *Church Belles*: both in terms of the software's ability to detect triggers from the instrumental input and the ability of the performer to perform these triggers accurately and reliably.

One of the advantages of working with interactive systems is the ability to record the pieces in one continuous take. This differs from contemporary recording practices of overdubbing, using multiple takes and the precise positioning of events in time. Although overdubbing of vocal and guitar parts may well be applicable to audio-only versions, the authenticity suffers and post-production times increase if this is done for video recordings of live performances.

As observed by Swenson (2012), working with interactive systems also involves the implementation of live mixing processes. Filters, compressors, limiters and dynamic mixing techniques (such as sidechaining) were used extensively to ensure clarity and avoid clipping, especially when a system's output was more unpredictable due to the use of live performer input. Figure 56 shows the typical use of mixing devices for the 'multi-tool' and 'metaphor' pieces. Mixing techniques used to attain a fuller, more even sound in popular music recordings (such as parallel compression and reverb) were used for the final recordings but avoided in performance in order to retain a rawer feel and more space in the sonic landscape.

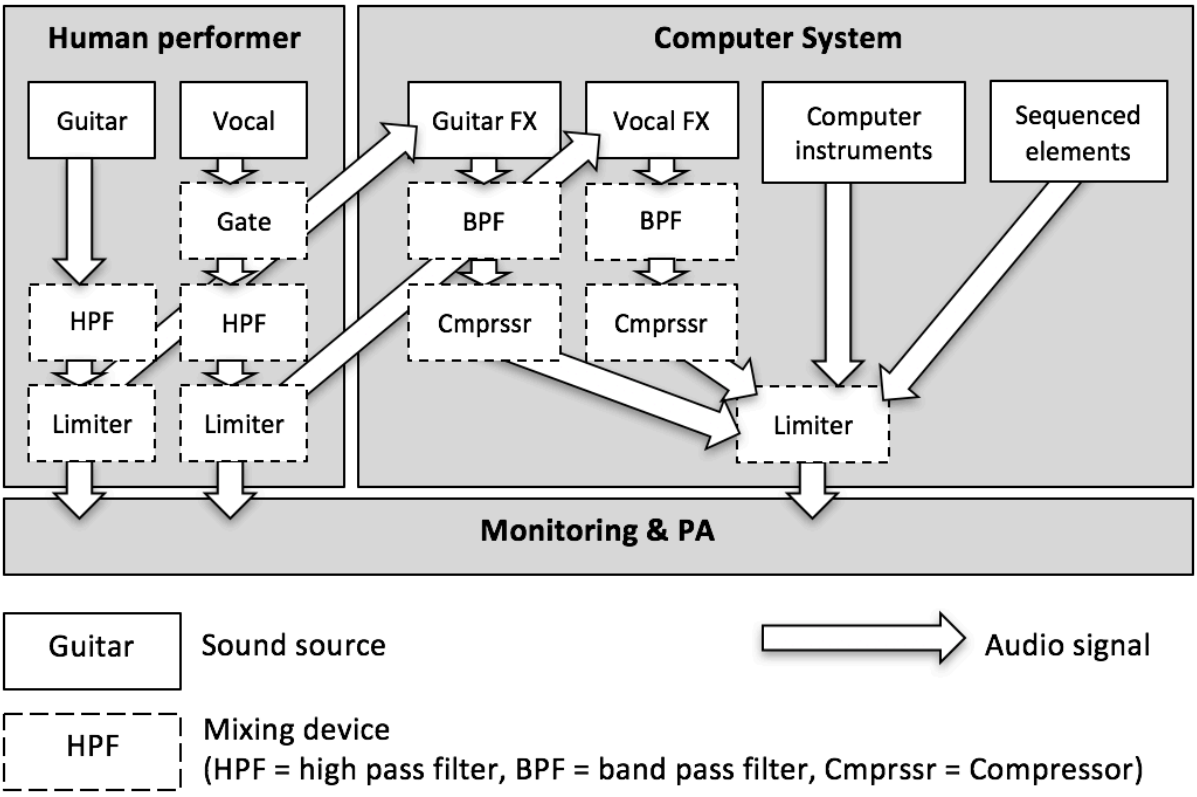

Figure 56: Live mixing processes used in the systems using live guitar and vocal input.

4.2.5. Experiential impacts

The impact of multi-tasking when working with interactive systems is significant. In the 'multi-tool' and 'metaphor' pieces, creating and configuring system elements while singing and playing guitar was extremely challenging. The combined inertia of this simultaneous activity means that taking new compositional directions feel like an overwhelming task. Interacting with the system through other means (such as standard MIDI controllers) can make this easier. For example, in *Church Belles*, a MIDI controller was used to 'ring' the bells in place of the guitar during initial testing and experimentation. Later compositional decisions were taken following direct manipulation with the system using a mouse. In the 'explorative-generative' and 'typing' pieces, the use of the *Nanokontrol* facilitated the incorporation of dynamics, rather than having to program presets and parameter changes controlled by a score-follower.

Working with interactive systems also increases the time spent working on a piece due to the need to create and configure software and rehearse with unfamiliar processes. Additional time pressures outside of the songwriting process include such creating visuals and designing device interfaces. However, the impact on time can be mitigated by the recycling and refining of devices, tools, techniques, resources and approaches over repeated compositions. Furthermore, using well-supported languages aimed at artists such as Max and Processing makes system development feasible for non-computer scientists. What might be lost in terms of processing efficiency is offset by the reduced learning curve. Max for Live facilitates a highly focused, modular approach within a familiar environment with access to control routing, audio routing and transport functions as well as software instruments and effects. The expansive, flexible yet focused environment helps to prioritise the ultimate goal of composition when creating system tools.

Where there was a unity between the system and the compositional themes, as in the pieces using the 'typing' and 'metaphor' approaches, the overall process was streamlined by memetic agency. For example, the use of text processes in *Leave My Room* naturally suggested literary themes, Morse code beeps and typing sounds and the use of Morse code while the use of bells in *Church Belles* naturally links to the theme of marriage and bell sounds. This constituted a clear defining of the problem space, in which there were less possibilities to explore, both artistically and technologically. In *Willow* and *Unquiet*, where there were no thematic connections between the song and the system, the presence of too many possibilities was partially solved by using the live instrumental and/or vocal input to create system output.

4.2.6. Summary

- Interactive systems can be used to generate initial song ideas. They may influence a song's development through performative (through its musical output) and/or memetic agency (through thematic connections).
- Interactive systems can be introduced at the arrangement stage to add additional layers to existing instrumental/vocal parts.
- When working with interactive systems, rehearsal/performance and recording are essential to check the operation of the system, the capabilities of the performer and to facilitate reflection. The ability to record multiple layers in one take is a distinct advantage.
- Though working with interactive systems will result in additional time pressures, these can be offset through recycling tools and techniques and choosing a well-supported programming language.

These findings will be reiterated and further discussed in 6.1.1.2.

4.3. Implementing interactive systems at different stages of the process

As well as pieces that used interactive systems throughout the songwriting process, the portfolio also includes pieces where systems were introduced at specific stages as part of a broader process involving other techniques (see Table 2). For example, the initial song creation of *Unquiet, Brains Need Bodies Too* and *Piece for Tape* took place before the implementation of the interactive systems, which were used to create indeterminate accompaniment to existing guitar, vocal and electronic drum parts. This was achieved through the use of devices that transformed representational data from instrumental input

(e.g. *Gen_Arp*) and devices that processed instrumental/vocal audio input (loopers and granular synthesisers).

The introduction of the system at the arrangement stage meant that its agency over the composition was limited. However, in *Brains Need Bodies Too* and *Piece for Tape* both performative and memetic agency were maximised by adapting the arrangements to make room for the systems' audio output to be foregrounded and by thematic links between the system and the lyrics. This will be examined further in the discussions of interactive liveness and aesthetic liveness in 5.3 and 5.4.

Broken Starling was unique in the portfolio in that the system was not implemented until the performance stage. Creating a live version was particularly challenging as the piece had been fully composed within in a DAW, did not involve a guitar part and contained several sections that were unique in terms of rhythm, harmony and dynamics. As discussed in 3.5.4.3, the strategies of modelling the original found sound source in software; transferring the bassline to a live guitar part; including pre-sequenced material where necessary and creating reflexive system elements linked to the physical model resulted in a successful live version.

The development of *I Begin Where You End* was also unique in that an interactive system was used for the initial song creation, before using a DAW for arrangement and production. Once the system had been created and audio material selected, the functionality of the complex sequencing tool (discussed in 3.2.2.1) enabled extensive improvisation that generated the main elements of the song. These elements were then transferred to a DAW for further arrangement, which involved substantial alteration to the existing material and the creation of new elements. Like *Broken Starling*, because of the extensive use of linear DAW techniques, the recorded version could not be recreated live without the use of pre-sequenced material lifted directly from the recording. However, because the system had been used for the initial stages of composition and could be used to generate multiple layers of audio, it was decided to create a radically different live version. As mentioned in 3.2.4.2, when compared to the recorded version, the live version features a simpler overall structure, less nuanced phrasing of individual elements, less ornamental detail, softer sectional

boundaries and greater rhythmic ambiguity. However, the avoidance of pre-sequenced material and the freedom to improvise in performance meant that this approach was much more satisfying than attempting to recreate an idealised recording.

To summarise the above:

- Interactive systems can be introduced at any stage in the songwriting process.
- The earlier it is introduced, the more influence it will have over the final piece, unless it is decided that it will be used to create a radically different version of the existing song. (This will be discussed further in 6.1.1.2).

4.4. Combining interactive system output with popular music features

This section discusses the implementation of the strategies (mentioned in 2.1.4) for creating coherence between the often chaotic, indeterminate musical structures resulting from the use of interactive systems with the composed rhythmic, melodic and harmonic features of popular music. The need for the system to demonstrate significant agency over a piece must be balanced with the potential disruption to the composed aspects.

4.4.1. Adaptation of human-composed elements

The first strategy involves adaptation of the human-composed elements of the piece to be compatible with the system. This is most evident in *I Begin Where You End*, where many of the features of the recorded version were replaced by the results of real-time system processes. A more organic approach was adopted in *Church Belles* through extensive

improvisation and rehearsal with the system before the guitar parts and vocal melodies were fixed. While the system exerted more influence over the instrumental and vocal parts when it was implemented early in the composition process (as in *Church Belles*), it still affected detailed aspects of their composition and performance when implemented at later stages. For example, the lyrics and/or vocal melodies of *Willow*, *Brains Need Bodies Too* and *Piece for Tape* were created and refined while listening to system output and aspects of the guitar parts in *Brains Need Bodies Too, Piece for Tape* and `*Broken Starling* were left unfixed to allow the human performer the freedom to respond to unpredictable system behaviours.

With the exception of the 'typing' pieces, lyrics were written once the music was mostly complete. As mentioned in 3.3.3.3, in an attempt to reflect the indeterminate qualities of the systems, the modernist approach of selecting words for their sonic qualities rather than meaning was adopted. Whilst useful in developing vocal melodies, it was very quickly discovered that on a personal level, meaning was essential in forging a deeper connection with the lyrics to achieve a suitably expressive performance. A process was therefore established whereby nonsense lyrics were crafted into a narrative, with care being taken to enhance rather than compromise the musical qualities of the words.

4.4.2. Use of unifying system elements

The second strategy relates to the creation of rhythmically and/or harmonically stable system elements to create a unity between the regularity of composed structures and the more chaotic audio output of a system's indeterminate processes. All of the pieces use either regular, repetitive percussive elements (*Leave My Room*, 'multi-tool' and 'metaphor' pieces); drones ('explorative-generative' pieces, *Kafka-Esque* and *Piece for Tape*) or sequenced melodic elements (*Unquiet, Brains Need Bodies Too,* and *Broken Starling*). This established perceptual coherence by emphasising the pulse of rhythmically ambiguous material (*I Begin Where You End* and *Leave My Room*) or providing a stable harmonic context for improvisation with the system (*Brains Need Bodies Too* and *Piece for Tape*).

4.4.3. Incremental fixing of system outputs

While facilitating the generation of ideas during early stages of songwriting, the unpredictability of the system output could result in the disruption of the composed elements of the piece in performance. One possible solution, the curation of recorded system output for use as fixed material, was not appropriate here as this would undermine the ability for each performed version to be unique. Instead, the range of possible system behaviours was increasingly constrained as the song neared completion. This was implemented through a combination of:

- Global constraints hard-wired into the system.
- Structure-constraints linked to a score-follower.
- Real-time constraints involving the mapping of system parameters to representational data from the live instrumental/vocal elements or MIDI controller.

Global constraints include:

- Linking guitar pitches to the 'ringing' of bells via one-one mappings for the lower bells and one-many mappings for the higher bells in *Church Belles*. This maintained clarity in the lower frequencies while allowing a more ambiguous, textural effect in the higher frequencies.
- Quantising MIDI events at short time intervals to increase rhythmic coherence in *Church Belles, Broken Starling* and *Piece for Tape* without breaking audio-visual relationships (e.g. bell collisions in *Church Belles*).
- Applying band-pass filters and compression on audio input-derived effects in the 'multi-tool' and 'metaphor' pieces to achieve a clearer and more stable mix (see Figure 50).
- Using short, repeating sequences of pitches to maintain the harmonic and melodic coherence of the generative melodies in the 'typing' pieces, *I Begin Where You End* and *Willow.*
- Filtering MIDI events to reduce the note density of *Willow's* input-derived rhythm generator and eliminate undesirable pitches generated by *Gen_Arp* in *Unquiet*.

- Use of resonators on looper tracks in *Brains Need Bodies Too* to support the harmonic context.
- Reducing the length, reducing the dynamic range and increasing the attack times of samples in *I Begin Where You End* and *Church Belles* to increase overall clarity.

As detailed in 3.3.2.3, structure-constraints in the 'multi-tool' and 'metaphor' pieces were implemented through the use of a score-follower that detects the current section of the song from the guitar part. Because the 'explorative-generative' and 'typing' pieces do not involve guitar, structure-constraints are applied by the performer using a *Nanokontrol*. Structure-constraints ensure consistency with human output, minimise the unwanted results of indeterminate processes and enhance the expressiveness of the score while maximising flexibility in terms of the length of each section, improvisation by the human performer and indeterminate system output. Structure-constraints include:

- Adjusting the volumes of system audio elements (all pieces).
- Adjusting playback settings of loopers in the 'multi-tool' pieces, *Piece for Tape* and *Broken Starling.*
- Altering the behaviour of the physical model in *Church Belles* and *Broken Starling.*
- Adding and removing system elements in *Piece for Tape.*
- Controlling the playback of sequenced elements in *I Begin Where You End*, 'multi-tool' and 'metaphor' pieces.
- Adjusting audio effects parameters in the 'typing' pieces.

Real-time constraints include:

- Controlling individual sequencer elements with *Launchpad* keys in the 'explorative-generative' pieces.
- Linking the activation of looping and spectral effects to the live guitar volume in the 'multi-tool' pieces.
- Activating the recording and playback of captured typing rhythms with modifier keys and the *return* key in the 'typing' pieces.

- Transposing the pitch of a sequenced bassline to the lowest note in an arpeggiated guitar chord in *Brains Need Bodies Too* and *Church Belles*.

4.4.4. Foregrounding/backgrounding of human and system elements

The pieces in the portfolio demonstrate significant variety in terms of how the human-created (including pre-sequenced material) and indeterminate, system-created elements are balanced in terms of foreground and background. Pachet's (2006) interaction protocols can be applied to the categorise the real-time relationships that impact on this balance. *Collaborative* and *accompaniment* interactions are indicative of a background role for the system, whereas the more conversational *turn-taking* interactions allow a more foregrounded role.

Collaborative interactions are particularly evident in the devices that provide continuous, automatic background accompaniment to human-created elements. The outputs of these devices are tightly constrained, run continuously and are controlled automatically by the system. Examples include *Gen_Arp* in *Unquiet*, the granular synthesis and rhythm generators in *Willow* and the washing machine collisions in *Broken Starling.* Real-time audio effects processing on instrumental/vocal elements in *Willow, Church Belles* and *Broken Starling* can be considered to be *single-note* or *phrase-based accompaniment* interactions, as they occur at the same time as human elements and are of limited duration. Again, these layers remain in the background.

The reflexive approaches in the looping devices of the 'multi-tool' pieces, *Piece for Tape* and *Broken Starling* and the artificial intelligence devices in *Brains Need Bodies Too* indicate a role for *turn-taking with delay* interactions, due an intermittent system response that may significantly overlap with the human-created output. Where space is present in the arrangement through the reduction of human audio output and relaxing the need for adherence to strict harmonic/rhythmic structures (e.g. the improvisation sections in *Brains*

Need Bodies Too, Broken Starling and *Piece for Tape*), the output of these devices can be foregrounded.

Because Pachet's protocols are only designed to apply to reflexive systems, applying them to the pieces that involve playing on the system is more difficult. However, *turn taking* might be an appropriate characterisation of the interactions in the 'explorative-generative' and 'typing' pieces, as the human performer often alternates between controlling the system and listening to the results. As with the improvisation sections discussed above, the reduced presence of human-created elements and fixed harmonic/rhythmic structures meant that the system output could be foregrounded throughout these pieces.

4.4.5. Summary

Strategies for combing the audio output of interactive systems with the composed structures of popular music include:

- Adapting the human-composed popular music structures through the application of algorithmic processes to the composed material or through improvisation with the system.
- The use of harmonically and/or rhythmically stable system elements to exert a perceptual pull on the interactive system output.
- Limiting the system response through global constraints hard-wired into the system, structure-constraints that vary during the course of the piece and real-time constraints that can be directly manipulated by the performer.
- Using appropriate modes of interaction to allow the system audio output to be backgrounded or foregrounded.

These strategies will be reiterated and further discussed in 6.1.1.3.

4.5. Combining electronic system output with human instrumental/vocal sounds

In presenting human instrumental/vocal output alongside a system's electronic output, there needs to be a balance between

- maintaining a degree of separation to allow for the distinction between human and system output and
- connecting the two realms to present a cohesive whole.

While the system's visual components will impact on this relationship in a performance context, this discussion in this chapter will be limited to an audio perspective. This is to maintain the relevance to songwriting as a whole and to account for the potential for audio-only versions of the pieces to be created. The role of visuals in maintaining separation and creating cohesion will therefore be covered as part of the discussion of liveness in Chapter 5.

4.5.1. Maintaining separation between human and system outputs

Separation between human and machine audio output is maintained in two ways. Firstly, the innate human-like and machine-like qualities of instrumental/vocal and system audio output is retained. Secondly, where instrumental/vocal audio is incorporated into the system, various techniques were applied to make it machine-like. This section explores these two strategies in more detail.

The emphasis of machine-like qualities in the system is mostly achieved through timbre. Electronic sounds are used for the drums and synthesisers in *Unquiet* and *Brains Need Bodies Too*, whilst mechanical sounds are used in the 'metaphor' pieces. *Church Belles* also emphasised the virtual nature of the system by making use of behaviours that would be impossible in the physical world.

In order to retain human-like qualities, vocal and guitar parts are only lightly processed. When system output includes substantial real-time processing of the vocal or guitar, the human output is still foregrounded to enable the processed layers to be perceived as system output (e.g. vocal processing in *Church Belles* and *Broken Starling*). When human audio output is incorporated into the system through looping, sampling or playback of pre-sequenced material, various techniques bring the material into the realm of the machine. These include:

- Extensive destructive timbral processing e.g. filtering the looper output in 'multi-tool' pieces and *Piece for Tape* and pitch shifting the vocal in *Church Belles*.
- Creation of un-natural, machine-like gestures e.g. envelope processing of looped vocals in *Unquiet;* noise bursts interrupting the loopers in *Brains Need Bodies Too*; timbral shifts between samples in *I Begin Where You End* and granular synthesis to create drones in *Willow* and *Piece for Tape*)
- Layering of recorded human sounds with electronic sounds e.g. vocal samples in the 'typing' pieces and the sequenced bassline in *Unquiet*.

While the 'typing' pieces do not involve traditional instrumental/vocal performance, the act of typing becomes its equivalent. The human performer therefore prioritises natural typing gestures and expressivity over rhythmic synchronisation. In *Leave My Room*, this creates a stark contrast with the machine-like Morse code rhythms produced by the system.

4.5.2. Creating cohesiveness between human and system audio outputs

Figure 57 classifies the sound sources used in the portfolio by locating them in overlapping human, machine and natural realms. By locating sounds on a dimension of 'perceivable physicality', it highlights where cohesiveness between sounds needed to be enhanced in order for pieces to be perceived as a whole rather than separate instrumental/vocal and electronic layers. This was achieved in four ways: creating perceptual continua; creating

behavioural links from representational data; re-embodiment of system sound and deterritorialisation/de-embodiment of instrument/vocal elements. The rest of this section will examine these techniques in more detail.

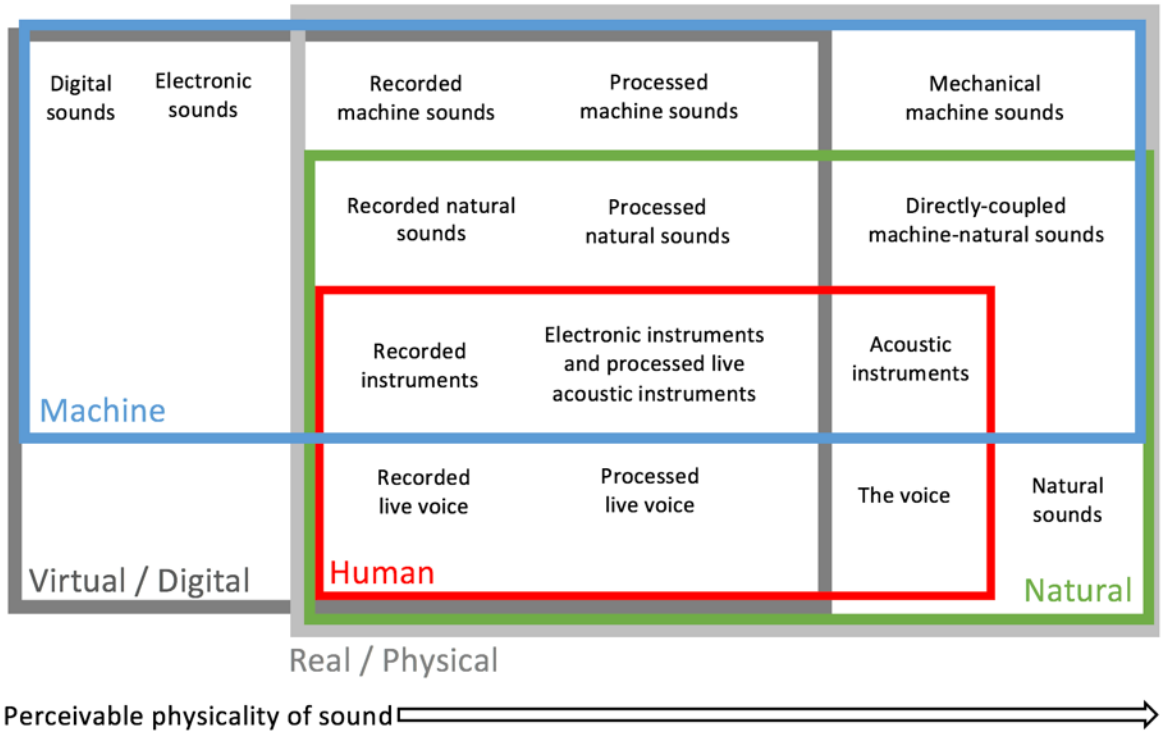

Figure 57: Categorisation of material used in the portfolio pieces.

In the pieces involving both guitar and vocal, the instrumental/vocal elements become the source material for the system, brought into the realm of the machine using the techniques mentioned in the previous section. Perceptual continua with the human output can be established as long as some recognisable characteristics are retained. This technique is evident in the use of real-time vocal processing in *Church Belles* and *Broken Starling* and the use of loopers and granular synthesis in the 'multi-tool' pieces and *Piece for Tape*.

Behavioural links are established through deriving system audio outputs from real-time representational data created from instrumental/vocal elements. For example, MIDI data derived from the guitar part control melody generation with *Gen_Arp* in *Unquiet* and artificial intelligence devices in *Brains Need Bodies Too*. Representational data from the guitar part also controls rhythm generation and effect activation in *Willow*.

The re-embodiment of electronic sounds is achieved through indicative links to real objects and processes. This is especially evident in the 'metaphor' pieces, where the systems were modelled on physical objects and therefore suggested the use of related audio outputs. The bell sounds in *Church Belles*, tape deck sounds in *Piece for Tape* and washing machine collision sounds in *Broken Starling* were all suggested by the system. Similarly, the systems in the 'typing' pieces suggested the use of keyboard and voice sounds (*Kafka-Esque* and *Leave My Room*) and sine wave beeps (*Leave My Room*). As well as system links, cohesiveness can also be enhanced through the connection of sounds to the compositional themes (Smalley, 1996). The lyrics, sounds and systems of *Brains Need Bodies Too,* the 'metaphor' and the 'typing' pieces are all directly linked by their underlying themes.

In the systems where the electronic system output is dominant, cohesiveness was achieved through disembodying instrumental/vocal sounds. The 'typing' pieces deliberately deterritorialised both voice and guitar in pursuit of a more experimental aesthetic and partially disembodied the voice recordings through layering with synthesised elements. In *Broken Starling*, the dominance of pre-sequenced electronic sounds led to a less prominent role for the guitar as a human audio element. Instead, the more functional roles of replacing a sequenced bass part, controlling score-following and providing audio input for foregrounded looping effects were prioritised.

4.5.3. Summary

When combining human and system audio outputs:

- Separation between human instrumental/vocal and system elements may be maintained through retaining innate human-like and machine-like qualities. Where human elements are used in the system audio output, these can be processed to make them more machine-like.

- Cohesiveness between audio layers from different realms may be increased through the use of instrumental/vocal elements in system audio output; linking representational data from human elements to system parameters; connecting system audio output to real-world objects and/or compositional themes and by layering instrumental/vocal elements with system-produced sounds or removing them from a foreground role.

These points will be reiterated and further discussed in 6.1.1.3.

5. How does the use of interactive systems in songwriting impact on liveness?

In this chapter, the system approaches and pieces in the portfolio will be compared by the extent to which they reveal spatio-temporal, corporeal, interactive and aesthetic liveness. Implications for overall liveness will be discussed in Chapter 6.

5.1. Spatio-temporal liveness

5.1.1. Presence of the human and machine performers

The performances of the pieces of the portfolio aimed to present the human performer and interactive system as separate entities (spatio-temporal liveness) that demonstrate how they are creating sound (corporeal liveness) and how they interact with one another (interactive liveness). In this sense, spatio-temporal liveness potentially underpins corporeal liveness through providing a perceivable body to be the cause of system-produced sounds. It may also underpin interactive liveness as in order to be perceived as mutually influential, the human performer and interactive system must first be perceived as separate entities.

Establishing human and system elements as separate entities in terms of audio output was discussed in 4.5.1. The strategies for doing this can be summarised into two main groupings:

- Maintaining the innate human-like qualities of the human performer and the machine-like qualities of the system.

- Where the system's output included human-created material, subjecting it to heavy processing and layering to imbue it with machine qualities.

In performance, additional considerations pertaining to staging and system visuals come into play. In terms of staging, the presence of the machine was represented by the system hardware (laptop, audio interface, MIDI controllers, projector and screen) and the projected visuals. To give the impression of a partnership between human and system elements, the performer is positioned to the side of the visuals and turned slightly to allow them to see the projector screen. The use of mounted sensors and controllers on the body of the performer or instrument was deliberately avoided in order to maintain separation between human and system elements. The use of signal analysis in the 'multi-tool' and 'metaphor' introduced a greater separation than the tactile controllers used in the 'explorative-generative' and 'typing' pieces. However, the use of human gestures (typing gestures in 'typing' pieces) and vocals in *I Begin Where You End* serve to partially restore the distinction.

Separation between human and system in the visuals was maintained through the avoidance of anthropomorphisation approaches. (Petrozziello, 2015; Kirn, 2015a). As with the system audio, the visual output was kept deliberately machine-like. Although the HUD approach of the 'multi-tool' visuals involved human elements, these were designed to give the impression of being from the viewpoint of a machine performer who could 'see' and 'hear' the human performer. The layout of the visual elements, with human elements on the left and system outputs on the right (Figure 58) further emphasised the separation between human and machine.

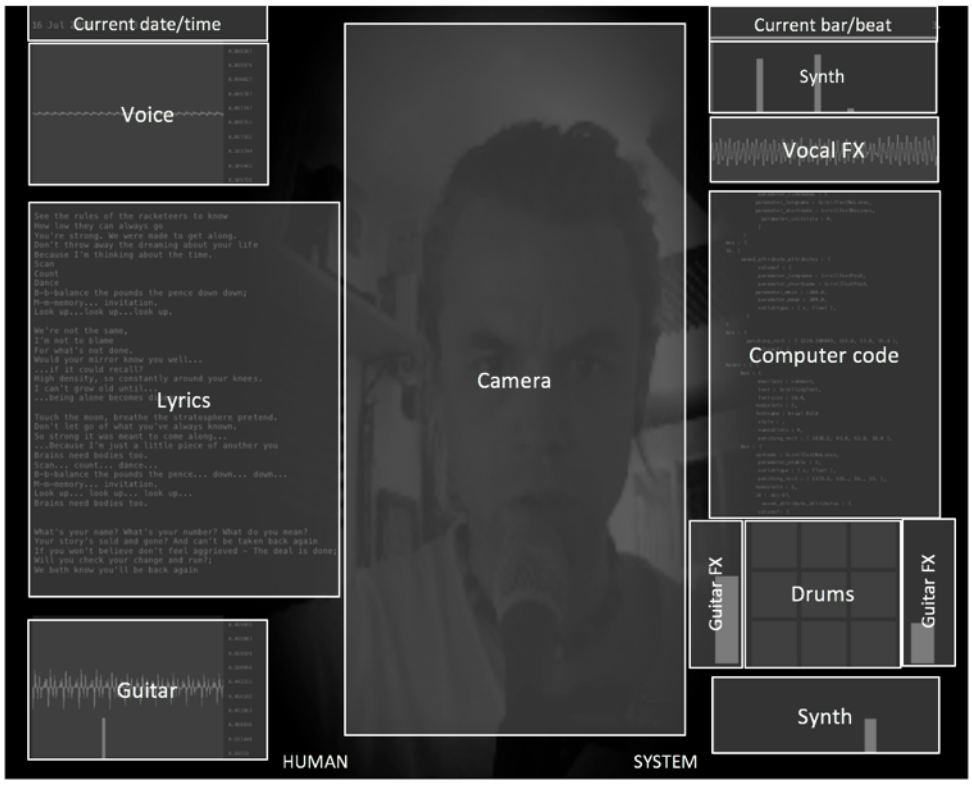

Figure 58: Annotated HUD visuals used in the 'multi-tool pieces. Human elements are represented on the left and system elements on the right.

5.1.2. Perception of the system as an active agent

As well as demonstrating presence in time and space, spatio-temporal liveness can be enhanced by the perception that the system is active. Although the pieces in the portfolio avoided systems that attempted to replicate a human performer, there is a sense of aliveness that results from a machine that demonstrates its status as an active agent. Three main strategies were used to show that system output is being generated in real-time rather than being pre-prepared audio and video. These were: demonstrating a readiness to respond, the incorporation of errors in audio and visual outputs and the display of real-time performance data.

The 'multi-tool' pieces, *Church Belles* and *Broken Starling* demonstrate their readiness at the start of a performance through their responsiveness to input: the slightest input from the guitar and/or vocal at the start of the performance would be mirrored by the 'listening' elements in the visuals. Similar to a word processor, *Leave My Room* displays a blinking cursor, demonstrating that the system is in a state of readiness and awaiting typed input. Both 'typing' pieces also incorporate the deliberate typographical errors that work against the idea of the system output being pre-prepared. Although not as obvious to the audience, *Brains Need Bodies Too* also allowed errors in the output of the Markov chains, which were replicated in the guitar part through the attempts of the human performer to follow the audio output of the system. In the 'multi-tool' pieces, the use of a live camera feed, time data (date, time, current beat position) and performance data from instrumental/vocal elements (Figure 58) also emphasised the existence of the system as a real-time entity.

5.1.3. Summary and comparisons

System approach	Piece	Separation			Aliveness		
		Staging	Control protocol	AV aesthetic	State of readiness	Obvious Errors	Real-time data
Explorative-generative	*Rows, Columns, Collisions*	✓	×	✓	×	×	×
	I Begin Where You End	✓	○	✓	×	×	×
Multi-tool	*Willow*	✓	✓	✓	✓	×	✓
	Unquiet	✓	✓	✓	✓	×	✓
	Brains Need Bodies Too	✓	✓	✓	✓	○	✓
Typing	*Kafka-Esque*	✓	×	✓	×	✓	○
	Leave My Room	✓	×	✓	✓	✓	○
Metaphor	*Church Belles*	✓	✓	✓	✓	×	×
	Broken Starling	✓	✓	✓	✓	×	○
	Piece for Tape	✓	✓	✓	×	×	×

Table 3: Comparison of aspects of spatio-temporal liveness between the pieces in the portfolio.

✓ = Present × = Absent ○ = Present and absent.

Table 3 summarises and compares aspects of spatio-temporal liveness across the portfolio.

As discussed in 5.1.1, three factors were identified that contributed to the presence of the human and system as separate entities. These were appropriate staging of human and machine performers; whether a tactile controller or signal analysis was used and the use of material from the machine or environmental realm in the audio and visual output. Section 5.1.2 suggests three factors contributing to the perception of the system's aliveness: establishing a state of readiness at the start of the performance, the deliberate display of errors and the use of real time data. Overall, this indicates greater spatio-temporal liveness for the 'multi-tool' and 'metaphor' system approaches, as these involve instrumental/vocal elements where the performer can be seen and heard to be playing *with* the system rather than *on* it and therefore higher levels of separation. The 'multi-tool' systems further enhance spatio-temporal liveness through 'aliveneness' due to the presentation of real-time data, inclusion of errors and indication of readiness to respond.

5.2. Corporeal liveness

5.2.1. Overall design approach

In line with Correia et al's (2017) recommendations, most pieces adopted either the *audio-visual entities* ('multi-tool' and 'metaphor' pieces) or *sounding figurations* (explorative-generative' pieces) as the most effective strategies to enhance corporeal liveness through links between audio and visual elements (see Table 4). While the visual effects and additional media in the 'typing' pieces are indicative of the *audio-visual reactions to interactions* approach, the live presentation of typed text in the 'typing' pieces and the flashing letters of *Leave My Room* also suggest the *audio-visual entities* approach.

The visuals for the 'explorative-generative', 'multi-tool' and 'metaphor' pieces aim to provide visual equivalents for all or most of the system sounds. Although this could result in an

overload of visual information, various aspects of the overall design reduce this risk. In the 'explorative-generative' pieces, the use of the *sounding figurations* approach to represent the system interface and its processes resulted in a simple overall design. Designing visuals for the 'multi-tool' pieces was more challenging due to the variety of different system processes and audio outputs. While the *audio-visual entities* approach was successfully used to create a visual element for each audio input and output, each element has a very simple design to compensate for the volume of information being presented and underlying processes are not revealed. In contrast, the 'metaphor' pieces involve fewer system processes, meaning that each visual element could have a more complex design.

System approach	Piece	Design approach			
		Audio-visual entities	*Interactive sounding shapes*	*Sounding figurations*	*Audio-visual reactions to interactions*
Explorative-generative	*Rows, Columns, Collisions*			✓	
	I Begin Where You End			✓	
Multi-tool	*Willow*	✓			
	Unquiet	✓			
	Brains Need Bodies Too	✓			
Typing	*Kafka-Esque*	✓			✓
	Leave My Room	✓			✓
Metaphor	*Church Belles*	✓			
	Broken Starling	✓			
	Piece for Tape	✓			

Table 4: Audio-visual approaches in the portfolio based on Ribas' (2014) taxonomy.

The layouts of the visual elements are also designed to assist audiences in making audio-visual connections. As mentioned in 5.1.1, in the 'multi-tool' pieces, the visual elements related to the human performer are positioned on the left, with the system audio outputs on the right. In *Piece for Tape*, the cassette images are positioned vertically according to whether they represented the playback of guitar, vocal or sequenced material and horizontally according to position in the stereo field (Figure 53). In *Church Belles*, the pitch of each bell determines its position and size (Figure 44).

As well as visual considerations, the choice of audio output also has a direct bearing on corporeal liveness. The use of sounds with strong external references (typing, bell, washing machine and tape sounds) further strengthens audio-visual links in the 'typing' and

'metaphor' pieces. The use of human-produced sounds in the 'multi-tool' systems also provide clues as to their source, but to a lesser extent due to use of extensive processing.

5.2.2. Revealing behaviours

In the 'explorative-generative' and 'metaphor' pieces, system processes are revealed by the movement of and collisions between entities (*Rows, Columns Collisions; I Begin Where You End; Church Belles* and *Broken Starling*) and the representation of recording and playback processes (*Piece for Tape*). In the 'multi-tool' and 'typing' approaches, visualising the processes behind sequenced audio, text-to-sound mappings, stochastic events or artificial intelligence event generation in a coherent way was extremely challenging. Instead, system sounds are re-embodied through synchronisation to a corresponding visual element. This strategy was applied to represent Morse code in *Leave My Room* (flashing text), the drum parts in the 'multi-tool' pieces (drum pads) and drum parts in *Broken Starling* (lights and dials on the washing machine).

As well as through visuals, re-embodiment can also take place through performer actions. In the 'typing' pieces, existing corporeal links between the performers typing actions and system response are enhanced by linking noise bursts and pitch changes to the system's visual responses (visual noise burst) and exaggerated performer gestures (when pressing the space bar specifically to action a pitch change).

Because the onsets of sounds are key in corporeal liveness (Sanden, 2013; Bown et al, 2014a), highlighting onset events in the visuals may help an audience to distinguish them from non-sound-producing behaviours. In *Rows, Columns, Collisions* and *I Begin Where You End*, the visibility of sound-producing elements is linked to their volume and row-column collisions are highlighted. In *Church Belles*, the bells briefly change colour whenever a collision between the bell's body and the clapper is detected. As well as highlighting onsets, gradually increasing the complexity of system behaviour can assist the audience in making

audio-visual links. The 'explorative-generative' pieces, *Broken Starling* and *Piece for Tape* feature a gradual introduction of elements while the guitar part of *Church Belles* is played more softly and sparsely at the beginning of the piece to enable a system response that gradually increases in complexity.

5.2.3. Summary and comparisons

Based on the above discussion, Table 5 compares levels of corporeal liveness between the different system approaches and pieces in the portfolio. *Clarity of design* is influenced by which audio-visual design approach is taken and whether all audio elements are represented; the simplicity of the design; the relationship between the layout of the visual elements and system audio outputs and whether the system audio outputs themselves provide clues to their source. *Clarity of behaviour* relates to whether underlying system processes are revealed as well as their results; whether onset events are highlighted and whether the system's complexity can be adjusted during performance to facilitate audio-visual connections.

System approach	Piece	Clarity of design				Clarity of behaviour		
		Approach	Simplicity	Layout	Outputs	Process	Onsets	Complexity
Explorative -generative	*Rows, Columns, Collisions*	✓	✓	✓	×	✓	✓	✓
	I Begin Where You End	✓	✓	✓	×	✓	✓	○
Multi-tool	*Willow*	✓	○	○	○	○	○	○
	Unquiet	✓	○	○	○	○	○	○
	Brains Need Bodies Too	✓	○	○	○	○	○	○
Typing	*Kafka-Esque*	○	○	✓	✓	○	✓	○
	Leave My Room	○	○	✓	✓	○	✓	○
Metaphor	*Church Belles*	✓	✓	✓	○	✓	✓	✓
	Broken Starling	○	✓	○	✓	○	○	○
	Piece for Tape	✓	✓	✓	✓	✓	○	✓

Table 5: Comparison of aspects of corporeal liveness of the pieces in the portfolio.

✓ = Present × = Absent ○ = Present and absent.

These comparisons suggest that the highest levels of corporeal liveness would be present when the system's visuals reveal the underlying processes of a simple model that controlled all aspects of the system's audio output. Although this was highly evident in the 'explorative-generative' pieces, the abstract nature of the systems and pieces removed any clear external references connecting the system to its audio outputs. *Piece for Tape* was particularly successful in demonstrating corporeal liveness, despite the cassette behaviour not always representing discrete audio events. Also highly successful was *Church Belles*, though this was slightly mitigated in terms of 'outputs' due to the lack of visual representation for the vocoded vocal, bass synth and drums.

5.3. Interactive liveness

5.3.1. Levels of interactivity in the portfolio

All of the pieces demonstrate some degree of performative agency by the interactive system. The complexity created by the 'explorative-generative' and 'typing' systems results in highly unpredictable output. This leads to *conversational* interactions (Johnston et al, 2008; 2009), with the human performer frequently stopping to listen to the system output and adjust system parameters with the *Nanokontrol,* before providing the next input on the Launchpad or keyboard. The 'multi-tool' and 'metaphor' pieces feature some system elements that are purely reactive to human input and are therefore *instrumental* (e.g. the spectral processing effect in *Willow* and the vocal effects in *Broken Starling*). The use of indeterminate processes to create accompaniment results in *ornamental* interactions in the sense that the human and system elements are largely autonomous. However, mutual influence between performer and system is significant, due to the use of live instrumental/vocal input, the mapping of representational human performance data to system parameters and the human performer adapting their performance in response to system output. Conversational interactions in the

'multi-tool' and 'metaphor' pieces occur when specific improvisation sections were created in the piece's arrangement (e.g. *Brains Need Bodies Too* and *Piece for Tape*) that enable the foregrounding of reflexive elements and improvised instrumental/vocal response (as discussed in 4.4.4).

Interaction between the human performer and the system may take place over different timescales and via multiple channels simultaneously. As described in 3.5.3, the system for *Church Belles* responds to specific notes in the guitar part that cause the bells to be rung. As well as producing bell sounds, the system also responds by pitch shifting the live vocal to create a backing vocal layer. The system's response to the vocal is immediate, whereas its response to the guitar is delayed. The human performer must listen to them both (while continuing to play) and make adjustments to their playing and singing as they see fit – which will again determine system response. This suggests a high level of interactivity where both conversational and ornamental interactions are happening simultaneously.

When considering overall interactivity, the impact of the score must also be considered. The 'multi-tool' pieces and *Broken Starling* feature several sections and/or extensive use of sequenced material. They are therefore highly reliant on score-following, both to create variation in system response and ensure coherence with the composed elements of the song. In these pieces, the guitar part (which contains the triggers for the score-follower) must be performed with a high level of consistency. The presence of a score is also evident in pieces using dynamic mappings or composed interactions, in which the system's internal behaviour significantly changes and/or the interaction with the human performer becomes more complex. Examples in the portfolio include *Church Belles* and *Piece for Tape*, where these changes are activated by a score-follower, again controlled by triggers in the guitar part. The performer's ability to vary the length of each section and the potential for the system's behaviour to inform their decision-making suggests a three-way interaction between human performer, system and score.

5.3.2. Making interactivity perceivable

The audience perception of interactive liveness will depend on the extent to which the two-way relationships between agents are revealed, which is in turn dependent on the perception of separate entities (spatio-temporal liveness) and the perceptions of causes of sounds (corporeal liveness). Although the score cannot demonstrate corporeal liveness as it does not produce sound, it can still have a spatio-temporal presence in the audience's perception which may be further reinforced by both audio and visual cues (Vines et al, 2006). Therefore, as well as demonstrating the mutual influence between the human performer and the system, strategies for maximising interactive liveness should involve methods for revealing the interactions of the human performer and the system with the score.

The agency of the human performer over the system can be established through the presentation of the controller interfaces and processes to the audience. In the 'explorative-generative' and 'typing' pieces, these interfaces are the *Launchpad*, the computer keyboard and the *Nanokontrol*. Both the *Launchpad* and the computer keyboard are key features of the pieces in which they are used, highlighted by the staging of the performance and their representation in the visuals. The 'typing' pieces further emphasise the means of interaction through the use of typing sounds and gestures in the systems' audio output and through the performer's exaggeration of typing gestures. In the 'multi-tool' pieces, representation of instrumental/vocal output in the system visuals demonstrate that the system is 'listening' to the human performer. In the 'multi-tool' and 'metaphor' pieces, the use of the human performer's audio in the systems' audio output demonstrates the existence of a relationship between what the performer does and how the system responds. However, other than highlighting the recording process in *Willow* and *Piece for Tape,* the exact control mechanisms are less clear than in the 'explorative-generative' and 'typing' pieces.

The agency of the system over the human performer can be revealed by the performer's indication that they are listening and responding to the system. This is inherent in the conversational interactions of the 'explorative-generative' and 'typing' pieces. Less obvious are the subtle variations by the human performer in the ornamental interactions of the

'multi-tool' and 'metaphor' pieces, though the foregrounding of conversational interactions in certain sections of *Brains Need Bodies Too*, *Piece for Tape* and *Broken Starling* as well as the majority of *Church Belles* offsets this.

The agency of the system over the score depends on the audience's realisation that the indeterminate system output each performance of the piece is a unique version. This uniqueness may be apparent through the complex/chaotic nature of the system audio output (e.g. *Gen_Arp* output in *Unquiet,* drums in *Willow*, typing rhythms and vowel melodies in the 'typing' pieces) and the revealing of complex/chaotic processes in the visuals (e.g. the 'explorative-generative' pieces, *Church Belles* and *Broken Starling*). The agency of the system may be further emphasised through the audio and visual foregrounding of interactions (e.g. recording processes in *Willow* and *Piece for Tape*).

The agency of the score over the system may be revealed by evidence of composed interactions. This may include a significant change in system behaviour, such as the ringing action in *Church Belles* or the addition of tapes in *Piece for Tape*; a sudden change in system response at a sectional boundary, such as sectional melodic and rhythmic shifts in the audio output of 'multi-tool' devices; or visual cues to indicate that score-following is taking place, such as displaying the current song section in the 'multi-tool' visuals. In the 'explorative-generative' and 'typing' pieces, this agency may be revealed by a shift in the way the performer interacts with the system, for example by using the *Nanokontrol* rather than the *Launchpad* or keyboard in the 'typing' pieces.

The agency of the human performer over the score may be revealed through audience understanding of how the performer moves the piece through the different sections. In the 'multi-tool' and 'metaphor' systems, this will depend on the audience being able to identify these triggers within the instrumental part. This is clearest in *Broken Starling*, which predominantly uses one very simple melody as the trigger to move between sections. At the end of some sections in the piece, the looping of short phrases of sequenced material builds up tension which is released by the performer playing a potentially recognisable trigger to move into the next section. In the case of the 'explorative-generative' and 'typing' pieces, the

use of the *Launchpad* and *Nanokontrol* to implement changes to system functioning could also be perceived as the human performer controlling the score as well as the score influencing the system.

The agency of the score over the human performer can be assumed to be evident due to the presence of a sectional structure in all of the portfolio pieces. These clearly indicate that the human performer, while retaining ultimate control of the performance, is constrained by composed elements and the performances are not improvised.

5.3.3. The performer perspective

Because one of the advantages of working with an interactive system compared to a fixed backing track is increased flexibility, extensive use of pre-sequenced material can feel incredibly restrictive (e.g. *Unquiet* and *Broken Starling*). When essential for the expression of the score, it was trimmed down to its shortest possible length and looped. Whilst this removed some of the nuances and variation present in recorded versions of the songs, it enabled more flexibility in the instrumental part through removing the need to synchronise with long phrases and allowed the performer to extend or repeat certain song sections.

Although the score-following approach used with the 'multi-tool' and 'metaphor' pieces allowed considerable flexibility of the instrumental/vocal part within sections, performing the correct triggers at the correct time required considerable attention at the expense of listening and interaction, even with extensive rehearsal. Solutions to this included using non-time-critical triggers (*Church Belles* and *Piece for Tape*); using automatic triggers to change sections following a specified time interval (bridge sections in *Unquiet* and chorus sections in *Brains Need Bodies Too*) and simplifying the guitar part to allow triggers to be more easily played and detected (*Broken Starling*). Among the 'multi-tool' and 'metaphor' pieces, *Willow, Church Belles* and *Piece for Tape* stood out in terms of expressiveness. These pieces were the

least reliant on pre-sequenced material and featured less restrictive approaches to score-following.

As well as removing the need for significant incorporation of sequenced material, the 'explorative-generative' and 'typing' pieces avoided a score-follower altogether, allowing the performer direct control of the system through the *Nanokontrol*. In the 'typing' systems, coupled with the ability to gesturally perform on the system through typing, this control led to performances that felt highly expressive. This was particularly the case with *Kafka-Esque*, which was less constrained by rhythmic aspects than *Leave My Room*. Both pieces allowed for real-time judgements to be made by 'feel', which is perhaps best exemplified by the looseness of the typing rhythms and the note durations in the space bar melodies.

5.3.4. Summary and comparisons

System	Piece	Audience perception of agency						Performer		
		Human ⬇ system	System ⬇ human	System ⬇ score	Score ⬇ system	Human ⬇ score	Score ⬇ human	Flexible score-following	Minimal pre-sequenced	Expressive
Explorative-generative	*Rows, Columns, Collisions*	✓	○	○	✓	✓	✓	✓	✓	×
	I Begin Where You End	✓	○	○	✓	✓	✓	✓	○	○
Multi-tool	*Willow*	○	○	×	○	○	✓	○	✓	○
	Unquiet	○	○	×	○	○	✓	×	×	○
	Brains Need Bodies Too	✓	○	○	○	○	✓	×	○	○
Typing	*Kafka-Esque*	✓	○	○	✓	✓	✓	✓	✓	✓
	Leave My Room	✓	○	○	✓	✓	✓	✓	○	○
Metaphor	*Church Belles*	○	✓	✓	✓	×	✓	○	✓	✓
	Broken Starling	○	○	✓	○	✓	✓	○	×	○
	Piece for Tape	○	✓	✓	✓	×	✓	○	✓	✓

Table 6: Comparison of aspects of interactive liveness of the pieces in the portfolio.

✓ = Most/present × = Least/absent ○ = Some/present and absent.

Table 6 summarises the above findings and compares the interactive liveness of each piece and system approach. Audience perceptions are broken down into the six relationships discussed in 5.3.2 and the performer perspective depends on three factors discussed in 5.3.3.

Comparing the system approaches suggests that the 'multi-tool' pieces demonstrated the least interactive liveness overall. Key factors in this are the reduced ability to communicate the uniqueness of a performance to an audience and less flexible approaches to score-following. More successful are the 'metaphor' pieces, with the exception of *Broken* Starling, due to extensive use of pre-sequenced material and a limited direct impact of the human performer on the system from both audience and performer perspective. The most successful pieces in terms of interactive liveness were the 'explorative-generative' and 'typing' pieces. These relied less on pre-sequenced material and score-following, which allowed for more spontaneity and flexibility.

5.4. Aesthetic liveness

5.4.1. Revealing memetic agency

While other forms of liveness focus on revealing the system, aesthetic liveness is concerned with revealing the composition itself. Through performance, the connections between a system's functioning, its audio and visual outputs and the composition can be made apparent. As discussed in 2.2.4, these connections are the result of memetic agency during the songwriting process.

In the 'explorative-generative' pieces, the compositions arose from experimentation with the system and were therefore expressions of what could be done using the sequencing tool. The visuals were designed to be a direct representation of the system and the interface, whilst

the choice of audio output was largely abstract. Although the algorithmic process used to select the samples in *I Begin Where You End* and the opaque lyrics support the overall experimental aesthetic of the piece, there are no clear thematic links between these aspects and the system that could be presented in performance.

The HUD visuals for the 'multi-tool' pieces were primarily designed to link to the themes of human-machine coexistence and conflict in *Brains Need Bodies Too*. While the same design concept is present in *Willow* and *Unquiet,* this reflects more general stylisation considerations (see 5.4.3) and a shared system approach rather than thematic connections. The system audio outputs of *Brains Need Bodies Too* are also strongly connected to the lyrics, with the glitchy processing effects and electronic timbres creating a stark contrast with the human input. In the other two pieces, the only similar link is the use of chinaware samples in *Willow.* While not perceptible to an audience, connections such as this still hold meaning for the performer and therefore may impact on the expressiveness of the performance.

Connections resulting from memetic agency during the songwriting process are prevalent in the 'typing' pieces. The pieces' themes are linked to the use of typing sounds and rhythms (both pieces), environmental sounds (both pieces) and Morse code beeps and rhythms (*Leave My Room*). The presentation of text as it was typed, the use of images and real-time image processing further supported the literary connections and themes of personal transformation. Personal connections to the material were established through creating bespoke sound recordings and by the use of the local area as the source of visual material. The inclusion of the still image and the two videos used in *Kafka-Esque* further connected to the piece's themes through the use of the computer keyboard to make contact with the visual artists[13].

The 'metaphor' pieces display the most unity in terms of linking the composition and the audio and visual outputs. The systems feature well-known physical and/or cultural objects,

[13] Darren Washington (photograph) and Toby Tomlins (videos).

which were deliberately selected for their wider associations as well as their sonic behaviours. Again, the use of meaningful audio material plays a role through the incorporation of bespoke recordings of church bells, washing machine drums and tape decks. As well as having meaning for the performer, the visual cues emphasise the external references of these sounds to an audience. The lyrics were also determined by the metaphor: *Church Belles* contrasted peacetime and wartime through the lens of a marriage; *Broken Starling* (washing machine) explored themes relating to family life while *Piece for Tape* (cassette) was about memory and the non-linearity of existence.

In order to make comparisons between the aesthetic liveness of the pieces and their corresponding system approaches, the above connections can be categorised as follows:

- Connections between the composition and the system's functioning.
- Connections between the composition and the system's audio outputs.
- Connections between the composition and the system's visual outputs.

5.4.2. Imagined causes of sounds

In order to maximise spatio-temporal, corporeal and interactive liveness, the pieces in this portfolio avoid virtual liveness through minimising the possibility for non-existent causes of sounds to be inferred. This was done by linking sounds to visual elements wherever possible (corporeal liveness) and by maintaining separateness between human and machine elements (spatio-temporal liveness). However, some of the pieces feature audio elements that are not linked to a corresponding visual object. These include the 'wind' and 'rain' devices in *Leave My Room*; the pre-sequenced material in *Broken Starling* and the vocoded backing vocals in *Church Belles*. While the latter was linked to the central metaphor, this may not be completely clear to an audience and may therefore suggest a hybrid human-machine entity.

5.4.3. Stylisation of visible performance elements

The visuals aimed to represent the systems in a stylised way to further engage the audience without creating additional layers of meaning that might detract from the songs' themes. As discussed in 3.3.2.5, the visuals for the 'multi-tool' pieces were initially based on a version of the systems' user interface (Figure 20). Whilst this was extensively re-designed in pursuit of the *technological sublime*, the principle that the visuals provide an audience interface as well as an interface for the performer remained. Just as a well-designed interface promotes engagement with a machine (Isaacson, 2012), the design of the system visuals will be key in engaging an audience. This may be especially important in situations where other aspects of liveness are less present.

The visuals for the pieces in the portfolio are mostly stylised to an acceptable level. The pre-existing central concepts in the 'explorative-generative', 'typing' and 'metaphor' pieces greatly helped with this by keeping the overall design simple. In contrast, the absence of a central concept for the 'multi-tool' pieces meant that one needed to be created (the HUD approach) in order to achieve a satisfactory level of design. The HUD approach also potentially provides a framework for presenting a large amount of information without overwhelming the audience. Like the use of HUDs in popular film, the visuals could be appreciated as a whole without requiring the audience to understand each element. In the 'typing' pieces, while the presentation of text with photographic media and image processing techniques did not really represent the machine, highly stylised visual components for both compositions were created that made use of the *audio-visual reactions to interactions* approach (Ribas, 2014). The least successful design in terms of stylisation was *Church Belles.* While effective as a physical model, the visual representation of the bells in could benefit from further refinement.

5.4.4. Summary and comparisons

A summary of the above findings is given in Table 7. Aesthetic liveness is broken down into the extent to which memetic agency is revealed, the absence of virtual liveness and effective stylisation. *Brains Need Bodies Too, Kafka-Esque* and *Piece for Tape* demonstrate the highest levels of aesthetic liveness due to the strong thematic relationships between composition, system functioning and the systems' audio and visual outputs; the absence of virtual liveness and the highly-stylised presentation of the visuals. Low ratings for *Willow* and *Unquiet* are due to the lack of memetic agency between composition, system and choice of audio and visual outputs.

System approach	Piece	Memetic agency revealed			Absence of virtual liveness	Stylisation of visual elements
		System-composition	Composition /system-audio	Composition /system-video		
Explorative-generative	*Rows, Columns, Collisions*	✓	×	✓	✓	✓
	I Begin Where You End	✓	×	✓	✓	✓
Multi-tool	*Willow*	×	○	×	✓	✓
	Unquiet	×	×	×	✓	✓
	Brains Need Bodies Too	✓	✓	✓	✓	✓
Typing	*Kafka-Esque*	✓	✓	✓	✓	✓
	Leave My Room	✓	✓	✓	○	✓
Metaphor	*Church Belles*	✓	○	✓	○	○
	Broken Starling	○	○	✓	○	✓
	Piece for Tape	✓	✓	✓	✓	✓

Table 7: Comparison of aspects of aesthetic liveness of the pieces in the portfolio.

✓ = Present × = Absent ○ = Present and absent.

Having compared the pieces and system approaches in terms of aspects of liveness, summaries of these findings and discussions relating to overall liveness will be presented in Chapter 6.

6. Conclusions

This chapter will begin by drawing conclusions relating to the impact of using interactive systems on the songwriting process and liveness. Section 6.2 details further conclusions related to the artistic goals and method of the enquiry. Finally, recommendations are made in 6.3.

6.1. Conclusions arising from the research questions

6.1.1. How does the use of interactive systems impact on the songwriting process?

This section will discuss the extent to which system-building can be seen as composition; the impact on the overall songwriting process and strategies for combining the indeterminate structure and electronic timbres of the system audio with popular music features and human instrumental/vocal audio output.

6.1.1.1. System-building as composition

In 4.1, it was established that system-building can be positioned on a continuum between tool creation and composition. The position on the continuum will depend on several factors including the system's thematic links to the composition, its agency over the composition and whether it is being created for a particular composition or for more general use. Over the course of the portfolio, system-building was increasingly carried out within the context of a single composition rather than aiming to create tools for future compositions or other users.

This is exemplified by comparing the songwriting process for the 'explorative-generative' pieces, which focused on tool creation for multiple compositions, to that of the 'metaphor' pieces, in which a unique system was created for each piece.

The compositional activities of system-building can be categorised as construction and configuration. Construction involves creating a functioning system to establish a range of possible behaviours. Configuration involves controlling the ranges of these behaviours through mappings to human performer input, a score-follower or other system components. This distinction also applies to the incorporation of existing devices into the system, as these may require modification (construction) as well as mapping to other system components (configuration). Although part of system-building, the creation of purely functional devices, system visuals and device interfaces were not considered to be part of the songwriting process and are therefore not included in the model shown in Figure 64.

System-building as composition is perhaps most evident when direct exploration with a system's capabilities leads to the generation of significant compositional ideas that were not present at the start of the process. Creating a system around a central, unifying principle greatly assists with this by providing the composer with an interface for this exploration. This was evident in the 'explorative-generative' pieces, the 'typing pieces', *Church Belles* and *Piece for Tape.* In the 'multi-tool' pieces and *Broken Starling*, the systems comprised of multiple tools, each with limited influence over the composition. This made experimentation with the system less likely to significantly impact the composition.

6.1.1.2. Impact on the overall songwriting process

Sections 4.2 and 4.3 demonstrate that interactive systems can be used throughout the songwriting process (e.g. *Willow, Leave My Room* and *Church Belles*) or be introduced at any stage within it (e.g. *I Begin Where You End, Unquiet, Brains Need Bodies Too, Broken Starling* and *Piece for Tape*). Interactive systems can be used to create initial song ideas (*Leave My Room* and *Church Belles*) that can be further developed into a fixed recorded version using a

DAW (*I Begin Where You End*). They can be used to create arrangement layers to existing song ideas (e.g. *Unquiet, Brains Need Bodies Too* and *Piece for Tape*) or used to create a live version of a fully-written song (e.g. *I Begin Where You End* and *Broken Starling*). Implementing the interactive system at these later stages can still affect the composition. Ornamental arrangement detail may make a significant contribution (e.g. *Unquiet*); the song might be extended to incorporate improvisational sections (e.g. *Brains Need Bodies Too* and *Piece for Tape*) or a radically different version may result (*I Begin Where You End*). Their influence on the composition at each stage can occur through both memetic agency and performative agency within top-down and bottom-up processes respectively. Examples of these influences are summarised in Table 8.

Songwriting stage	Bottom-up/performative agency	Top-down/memetic agency
Initial song creation	Improvisation with unconstrained system response	Generating thematic ideas Setting overall restrictions
Arrangement	Improvisation with more constrained response	Suggest extension to thematic ideas Suggest possibilities for additional layers
Performance /recording	Constrained yet unique response Implementing mixing techniques	Ability to quickly create multi-track recordings

Table 8: Bottom up and top-down performative and memetic agency of interactive systems at different stages of the songwriting process.

The ability to use interactive systems at any stage or all stages of the songwriting process resulted in an extension to the model proposed in 4.2 to include system-building. System construction and configuration form merge with the three existing stages to become part of a cyclical process from which a finished version of a song emerges. The extended model of the songwriting process is shown in Figure 64.

The incorporation of an additional stage into the model suggests that the use of interactive systems may result in the songwriting process taking longer than with conventional approaches. This was particularly the case when working with systems involving guitar and voice, as creating and configuring the system while playing guitar and singing was a significant multi-tasking challenge. Though the learning curve involved in programming software may also contribute to lengthening the process, this can be offset by the use of

well-supported tools aimed at artists recycling of system devices, adopting a modular approach and by adapting existing systems and approaches. The creative process can be further streamlined through the use of systems that intuitively suggest audio/visual outputs and/or through the use of the live instrumental/vocal elements to create audio output. Perhaps most significantly, the existence of reliable and efficient signal analysis tools enables singer-songwriters to interact with systems without the need for major adaptations to their instrument or performance technique.

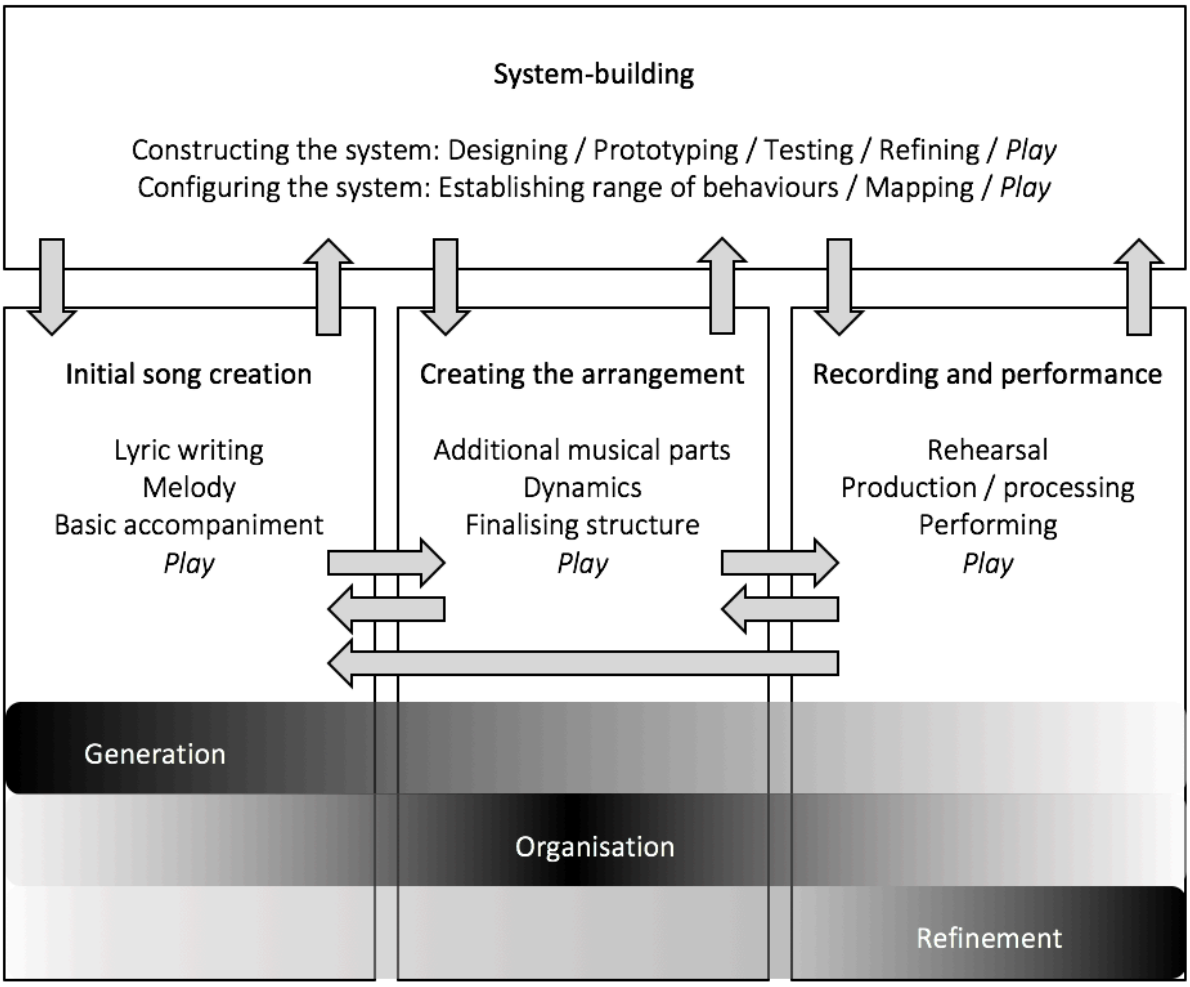

Figure 59: The songwriting process when working with interactive systems.

6.1.1.3. Combining system audio output with popular song elements

Despite the challenges involved in the use of interactive systems in popular songwriting (Bown et al, 2015; Marchini et al, 2017), various strategies were used to ensure the coherence of the systems' indeterminate output when combined with the structural, rhythmic and harmonic features of singer-songwriter material. Detailed in section 4.4, these can be summarised as:

- Adaptation of popular music features through improvisation with the system or through the application of experimental techniques.
- The use of unifying system elements such as repetition and drones.
- The incremental fixing of the system outputs using global (system/composition-level), structural (section-level) and instrumental (real-time) constraints.
- The foregrounding/backgrounding of human/system elements: for example, creating an improvisation section in which the human performer follows the system.

In addition, when combining the audio outputs of the system and human instrumental/vocal output, a balance must be struck between maintaining sufficient separation (to avoid *con-fusion* of realms) while ensuring an overall cohesiveness to the composition. In 4.5, it was proposed that separation might be retained by:

- the presence of live instrumental/vocal elements with minimal processing,
- the use of machine-like sounds in the system audio output and
- extensive processing of recorded instrumental/vocal elements or layering with electronic sounds;

while cohesiveness might be established through:

- the creation of perceptual continua by using instrumental/vocal elements in the system audio output,

- the creation of behavioural links by mapping of real-time, representational data from the instrumental/vocal input to the system's audio output and
- the re-embodiment of sounds through indicative links to real objects and processes, particularly those related to the system and/or the composition.

6.1.2. How does the use of interactive systems in songwriting impact on liveness?

This section draws conclusions from the comparisons of system approaches and pieces in terms of spatio-temporal, corporeal, interactive, aesthetic and overall liveness based on the findings in Chapter 5.

6.1.2.1. Impact on spatio-temporal liveness

Spatio-temporal liveness is dependent on the presentation of the human performer and interactive system as separate, active entities. Separation is affected by:

- staging considerations: the presence of system hardware, the presence of the system visuals and the positioning of human performer to suggest collaboration and
- method of system control: the avoidance of mounted controllers (on the guitar or performer's body) and whether the performer influences the system directly via a MIDI controller/computer keyboard or indirectly via the instrumental/vocal audio signal.

The 'aliveness' of the system is demonstrated by:

- its state of readiness at the start of the performance,
- the inclusion of errors in its output and
- presentation of real-time data in the system visuals.

Because all systems are staged in a similar way in order to present the performer and system as partners and involve visuals based around machine processes, the differences in separation ratings resulted from whether the human performer manipulates the system directly through an interface (playing *on* the system) or indirectly through the instrumental/vocal audio output (playing *with* the system). Direct manipulation suggests that the system is a tool or instrument to extend the human performer's capabilities rather than a separate performer with its own agency. The different ratings between *Rows, Columns, Collisions* and *I Begin Where You End* take into account the use of live vocal as well as direct manipulation, indicating that the presence of human instrumental/vocal output could potentially be considered as a separate factor. However, this was not done in this enquiry because for the vast majority of the pieces, the presence of human instrumental/vocal elements indicates the use of signal analysis.

The results reveal that system approaches and pieces vary considerably in terms of 'aliveness' cues, reflecting the difficulty of presenting the systems as active agents. The 'multi-tool' pieces are the most successful due to the ability of the HUD visuals approach to incorporate 'readiness' cues and real-time performance data. Other system approaches could potentially make of these aspects of the HUD approach, though care would need to be taken in terms of the amount of information being presented and the overall aesthetic impact.

6.1.2.2. Impact on corporeal liveness

Corporeal liveness is dependent on both the overall design of a system's audio and visual outputs and how these outputs are configured to behave in performance.

Factors influencing the overall design clarity include the audio-visual approach, appropriate levels of simplicity/complexity, appropriate layout of visual elements and selection of audio outputs. Overall, *Piece for Tape* is the most successful here as:

- each audio element is represented by a corresponding visual element in the *audio-visual entities* approach;
- a potentially overwhelming amount of visual information is avoided through the use of a metaphor to simplify the overall system design;
- each element was positioned in the visuals according to instrument type and position in the stereo field and;
- the image of the cassette is intuitively linked to the audio output.

In general, the portfolio pieces' visuals are more effective in terms of corporeal liveness when underlying system processes are revealed (rather than just their results), sound-producing events are highlighted and over-complexity is avoided through the gradual activation of each element. *Rows, Columns, Collisions* and *Church Belles* were rated particularly highly here. Both pieces reveal system processes that include non-sounding events, highlight sound-producing events and involve a gradual increase in complexity. In contrast, visual elements of the HUD visuals in the 'multi-tool' pieces reveal the results of processes rather than processes themselves, present continuous streams of recorded audio rather than discrete events and introduce multiple elements at once. *Broken Starling* involves the use of pre-sequenced material with no visual representation. Furthermore, sound-producing collisions in the physical model are not highlighted visually.

6.1.2.3. Impact on interactive liveness

In section 5.3, before making comparisons according to interactive liveness, the nature of the interactivity within the portfolio was examined. Pieces and system approaches demonstrate instrumental, ornamental and conversational interactions (Johnston et al, 2008; 2009) to different extents. The 'explorative-generative' and 'typing' pieces tend to involve conversational interactions, whereas 'multi-tool' and 'metaphor' systems exhibit instrumental and ornamental interactions. However, ornamental interactions were found to be bi-directional, while conversational interactions were introduced into *Brains Need Bodies Too* and *Piece for Tape* by the inclusion of improvisation sections and *Church Belles* through

the addition of the vocoded vocal layer. *Church Belles* demonstrates a high level of interactivity and suggests that conversational interactions may take place over very short timescales and simultaneously with ornamental interactions.

As well as considering interactivity between the human performer and the system, the score's ability to both influence and be influenced by the performance meant that it was also considered to be an agent. Due to the impact of performer confidence on audience engagement (Gurevich and Fyans, 2011) and the importance of the performer's experience (Reich, 2002), interactive liveness was considered from the performer perspective as well as the audience's.

When considering interactive liveness from the audience perspective, the inclusion of the score as an interacting agent meant that strategies such as revealing sectional triggers ('multi-tool' pieces and *Broken Starling*), emphasising changes in system response at sectional boundaries *(Unquiet, Leave My Room* and *Church Belles*) and visualising live recording processes (*Willow*) are on a par with demonstrating conversational interactions between the human performer and the system ('explorative-generative' pieces, 'typing' pieces, *Brains Need Bodies Too, Church Belles* and *Piece for Tape*). However, the overall stability in the systems' behaviour and sparsity of cues to suggest that the audio outputs are indeterminate resulted in lower ratings for the 'multi-tool' pieces. The pieces strongly support the idea that performances should aim to create aura rather than spectacle (Cascone, 2002a) by aiming to create unique versions (as opposed to recreating recordings) through a focus on the aesthetics of production (Ribas, 2014).

From the performer perspective, interactive liveness depends on the flexibility of the score-following approach, the minimal use of pre-sequenced material and the expressivity of the system. Higher ratings on these dimensions are linked to related types of liveness such as *liveness of spontaneity* and *liveness of fidelity* (Sanden, 2013) as well as the ability to create unique, authentic performances. Lower ratings were therefore evident in *Unquiet*, *Brains Need Bodies Too* and *Broken Starling*, which involve strict score-following processes controlling significant amounts of pre-sequenced material.

6.1.2.4. Impact on aesthetic liveness

Relating to the creation of meaning in performance, aesthetic liveness is dependent on revealing the thematic links between composition and system elements; the avoidance of unintended meanings created through *virtual liveness* (Sanden, 2013) and the stylisation of visual elements.

Thematic links between the composition and system can be established through memetic agency during the composition process. This can result in a strong sense of unity to the performance and the impression that the composition is about the system and the system is about the composition. This was particularly the case in the 'typing' and 'metaphor' pieces due to the connections between lyrics, system, structures and timbres of audio outputs and visual outputs. While this strongly suggests that the use of the system throughout the composition process will increase this unity, the system approach is also important. For example, the system did not inform most of the choices of audio outputs in *Rows, Columns, Collisions* but did suggest them in the 'typing' and 'metaphor' pieces. Whether suggested by memetic agency or not, the use of material that already holds meaning for the composer may facilitate expression and therefore meaning creation in performance on a subtler level. Examples of this include the use of found sound (*Willow*, *Kafka-Esque* and *Broken Starling*), the recordings of tape deck mechanisms in *Piece for Tape* and visual material in *Kafka-Esque*.

While virtual liveness may assist in the reception of recorded music (Sanden, 2013), it was considered to be a distraction from other aspects of liveness in this context. Because the overall aim was to reveal actual presence, actual causes of sounds and actual interactions, virtual liveness was avoided by maximising the other aspects of liveness, particularly by ensuring most audio elements had a corresponding visual element.

Most of the visuals were effectively stylised as suggested by Correia et al (2017). The redesigning of the original visuals for *Willow* to create the HUD themed visuals demonstrates the prioritising of this in the attempt to achieve the *technological sublime* (Demers, 2010).

Furthermore, the strength of this design concept influenced the composition of *Brains Need Bodies Too* and resulted in its use in all of the 'multi-tool' pieces.

6.1.2.5. Impact on overall liveness

Across the four approaches, the variation in levels of the different types of liveness strongly suggest support for the idea of *networks of liveness* (Sanden, 2013), where deficiency in one aspect can be made up for by another. The analysis in Chapter 5 suggest that nuanced factors such as use of pre-sequenced material (*Broken Starling*) and links between system and composition (*Brains Need Bodies Too*) have more impact on liveness than the system approach.

The multifaceted nature of each aspect of liveness suggests possible strategies when working with significant amounts of mediatised material and/or with systems whose functioning is hard to represent visually. For example, the liveness of *Broken Starling* may have been increased through the presentation of live performance data (spatio-temporal liveness), additional visual representation of pre-sequenced material (corporeal liveness) and visualisations of recording and playback processes (interactive liveness). The liveness of *Willow* and *Unquiet* may have been higher if they had used materials and processes that linked thematically with the composition (aesthetic liveness).

The use of a unifying design principle for both the system and the composition suggests links between aesthetic liveness and the other aspects. This is exemplified by the use of the cassette as an audio-visual metaphor in *Piece for Tape*. In this piece:

- Spatio-temporal liveness was supported by the visual presentation of cassettes, which are themselves a machine and therefore separate from the human performer's body.
- Corporeal liveness was supported through the use of recordings of cassette deck mechanisms.

- Interactive liveness was supported by the relationship of the recording and playback processes to the themes of the song.

The inclusion of aesthetic liveness allows for thematic as well as technological understanding. It also suggests a clear function for the system visuals: just as a well-designed machine interface helps the user to interact with it, the system visuals provide a way for the audience to engage with a performance through increasing understanding of both the system and the themes of the composition.

6.1.3. Links between the songwriting process and liveness

When working with interactive systems, the composition process will affect the liveness of the eventual performance. For example, during composition, human and the machine elements were deliberately kept separate to prevent the *con-fusion* of realms (Auslander, 2000). This directly relates to the perception of human and system elements as separate entities in performance and therefore spatio-temporal liveness. The strategy of creating cohesiveness through the use of instrumental/vocal elements in the system output establishes a connection between the human performer and system, suggesting interactive liveness. Interactive liveness is also affected by strategies to ensure coherence, such as structure-constraints implemented through score-following. Memetic agency is linked to corporeal liveness when systems intuitively suggest audio outputs that indicate a physical cause and to aesthetic liveness in terms of establishing connections between system and composition during the songwriting process.

A more subtle connection between the composition process and liveness is the use of material that is meaningul to the songwriter in the system audio and visual outputs. While the connections to the composition may not be directly observable to an audience, they assist in authentic expression, which is fundamental in singer-songwriter practice (Williams and Williams, 2016). Similar to the presentation of code in live coding, the audience's

engagement will be enhanced by the sense that while the exact meaning of what they see and hear is unclear, it is meaningful.

Perhaps the most significant connection however, is the presence of a central, unifying design principle. This results in an interface for the songwriter to directly experiment/play with the entire system in both composition and performance, while presenting the audience with an intuitive interface to actively engage with an interpretation of the system and the composition.

Similar to the impact of the recording process on songwriting (Hennion, 1990; Wicke, 1990), designing for liveness can exert a strong pull on the songwriting process. For example, the realisation that strong, real-world connections can benefit liveness resulted in their extensive use throughout the portfolio and not just in the 'metaphor' pieces. The high liveness ratings for *Brains Need Bodies Too*, the 'typing' pieces, *Church Belles* and *Piece for Tape* also lend support to the idea that as well as providing a shared point of understanding, the inclusion of real-world processes and allows composers and audiences to connect to higher truths (Xenakis, 1992; Emmerson, 2012b).

6.2. General conclusions

6.2.1. Reflection on method

The four approaches to interactive systems arose organically within a practice-based research methodology. Each approach informed the others, guided by the need to both extend and include traditional songwriting conventions, incorporate system-building into the songwriting process and explore different aspects of liveness. This process directly led to the inclusion of a wide range of styles in the portfolio, the increasing incorporation of system-building into the songwriting process and different approaches to demonstrating liveness.

Examples of links between the approaches include:

- The initial use of the 'explorative-generative' device in *Willow* to establish initial guitar parts and vocal phrase lengths.
- The use of 'multi-tool' devices to generate system audio output from instrumental/vocal elements in the 'metaphor' pieces.
- The use of text in the visuals for 'multi-tool' pieces and *Piece for Tape.*
- The use of similar rhythm generation devices in the 'typing' systems and *Willow.*

6.2.2. Reflection on the portfolio

This project resulted in the creation of ten original pieces of music at the intersection of popular and experimental music, that can be listened to through both participatory and intellectual methods. Table 9 details how the pieces in the portfolio demonstrate *cerebral sensuality* through the presence of the features of experimental popular music mentioned in 1.2.2.1.

Features of cerebral sensuality	Exemplified by…	Connects to…
Order & chaos	Contrast between song structures and indeterminate system output (throughout)	Use of chaos, algorithms and process techniques (Hansen, 2005)
Predictability & un-predictability	Foregrounding of system output within structures in *Brains Need Bodies Too* and *Piece for Tape*	Simultaneous acceptance and rejection of stylistic conventions (Moore and Ibrahim, 2005)
Simplicity and ambiguity /complexity	Constantly-changing melodies in 'typing' pieces, backing vocals in *Church Belles*, multiple tempi/phrase lengths in *I Begin Where You End* and complex rhythms in 'typing' pieces	Melodic, harmonic and rhythmic complexity (Lansky, 2005; White, 2005)
	Modernist influence on lyrical approach (throughout)	Complex/abstract lyrical themes (White, 2005)
Fixed & in-determinate	Use of *Nanokontrol* in 'explorative-generative' and 'typing' pieces) and sectional score-following in 'multi-tool' and 'metaphor' pieces	Use of chaos, algorithms and process techniques (Hansen, 2005)
Familiarity & unfamiliarity	Extension of song forms in *Brains Need Bodies Too* and replacing singing in 'typing' pieces	Simultaneous acceptance and rejection of stylistic conventions (Moore and Ibrahim, 2005)
Other features of experimental popular music	Noise and found sound elements of 'explorative-generative' and 'typing' pieces	Use of noise and found sound (White, 2005)
	Instrumental/vocal processing in 'multi-tool', 'typing' and 'metaphor' pieces	Use of processing to substantially alter the voice and traditional instruments (Hansen, 2005; Demers, 2010)
	Destructive processes of input-derived effects in 'multi-tool' pieces	Use of destructive techniques such as interruption (Moore and Ibrahim, 2005)
	Granular synthesis to create background textures in *Willow* and *Piece for Tape*	Use of textural and atmospheric layers (Moore and Ibrahim, 2005)
	Loud-soft dynamics in *Kafka-Esque*	Use of extreme loud-soft dynamics (Moore and Ibrahim, 2005)
	Subtly-changing rhythmic patterns in *Willow* and *Broken Starling* and timbral variations in *I Begin Where You End*	Rhythmic subtlety/timbral variation in the machine elements (Winkler, 2001)
	Substantial agency by the system in composition (throughout)	Use of electronic technology as a compositional tool (White, 2005)

Table 9: Evidence of cerebral sensuality and links to features of contemporary experimental popular music.

Consistent with Prior's (2009) observations on the influence of tools over a composition, the use of alternative control protocols in the 'explorative-generative' and 'typing' pieces resulted in a more varied, experimental aesthetic. The use of guitar and vocal in the 'multi-tool' and 'metaphor' pieces reveal a more consistent idiolect, though the influence of the system remained significant.

6.2.3. Overall conclusion

This thesis and accompanying portfolio demonstrate how interactive systems can be incorporated into all stages of the songwriting process. Traditional singer-songwriter practices have been combined with experimental real-time techniques, resulting in ten compositions at the intersection of popular and experimental music. The variety of system approaches used reveal how high levels liveness can be achieved in performance through focusing on different aspects of a network of liveness (Sanden, 2013). Rather than seeking to recreate an idealised version of a work (Cascone, 2002a), the interactions between the human performer, the system and the score result in unique versions of the songs being created each time they are played. Together with the emphasis on revealing system processes and compositional themes to the audience, this serves the ultimate goal of performance in bringing together the artist, the work and the audience in a shared, unrepeatable moment in time (Brown, 1999).

6.3. Recommendations

6.3.1. System/composition developments

As well as the suggestions for developing the individual pieces highlighted in Chapter 3, there is significant potential for the further development of the four system approaches.

The 'explorative-generative' approach resulted in the creation of a versatile tool that could be used in multiple compositions, either as the main device or as part of a network of system elements. Clearer sectional transitions and/or hands-free operation (e.g. to enable use with guitar) could be achieved through the use of score-following.

The 'multi-tool' approach would benefit from the inclusion of bespoke visual elements that better portray the system processes and link to compositional themes. For example, *Willow* might incorporate a real-time process for generating cracking patterns found in ceramic glaze (Wade, 2007), linked to the real-time production of rhythms and textures.

The visuals of the 'typing' pieces could include more text effects (Maeda, 1998; Lee and Essl, 2016) that reveal the system's audio processes and communicate composition themes. The spatio-temporal, corporeal and aesthetic liveness of these systems might be further enhanced by replacing the computer keyboard with a modified typewriter (Lepri and McPherson, 2018), which suggests separation from the computer system and offers the use of richer, mechanical sounds.

As demonstrated by *Church Belles* and *Broken Starling*, a single metaphor may not be sufficient to represent all of the system processes within a composition. Additional processes could therefore be represented visually, perhaps by using dynamic resizing of visual elements to avoid overwhelming the audience with too much information. The metaphor approach also offers rich ground for further exploration of real-world behaviours.

In terms of more general system developments, avenues for future work include further exploration of the aesthetics of production (Ribas, 2014) involving dynamic system behaviour and composed interactions (discussed in 2.2.3). The potential of the voice and guitar to provide the audio input for system response and function as a controller could also be further exploited, as this offers reliable communication with the system, connects the audio outputs of human and machine performers and enables singer-songwriters to perform in a familiar way. Finally, the principle of overall design unity that (the connections between the system's functioning, its audio and visual outputs and the composition as discussed in 5.4.1) provides a framework to facilitate exploration during composition and maximise liveness in performance.

6.3.2. Theoretical developments

In terms of studying the songwriting process, further work could involve the creation and use of interactive systems in collaboration with multiple human musicians as well as creating autonomous machine performers for robot ensembles such as *Musebots* (Bown et al, 2015). Interdisciplinary collaborations might also be studied, for example working with games programmers, computer scientists specialising in HCI and machine learning, photographers and film-makers.

In terms of liveness, several recent studies explore artist intention and audience responses in the field of audio-visual performance. The results are analysed using concepts related to liveness including understanding, engagement, enjoyment and transparency (Bin et al 2016; Correia et al, 2017; Weisling et al, 2018). Further work could explore the relationship of Croft's (2007) and Sanden's (2013) theories to these concepts in order to incorporate them in an expanded network of liveness. This could lead to a more nuanced understanding of how the use of interactive systems for the performance of popular music might further bridge the gap between art/reflection and life/being (Brown, 1999).

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8. Appendices

8.1. Publications and selected presentations

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Waite, S. (2015). Reimagining the Computer Keyboard as a Musical Interface. In: *Proceedings of NIME 2015*. Baton Rouge, LA. pp. 168–169. Available at: http://www.nime.org/proceedings/2015/nime2015_193.pdf

Waite, S. (2016). Church Belles: An Interactive System and Composition Using Real-World Metaphors. In: *Proceedings of NIME 2016*. Brisbane, Australia, pp. 265–270. Available at: http://www.nime.org/proceedings/2016/nime2016_paper0052.pdf

Waite, S. (2017a). Liveness and Interactivity in Popular Music. Innovations in Music 2017. London, UK.

Waite, S. (2017b). The Use of Metaphor in Interactive Systems for Singer-Songwriters. Tracking the Creative Process in Music 2017. Huddersfield, UK.

8.2. Selected performances

Noisefloor Festival, Staffordshire University (2011-7)

Rows, Columns, Collisions; Willow; Kafka-Esque; Church Belles and *Piece for Tape*.

MTI Concert/Seminar Series, De Montfort University (2012-7)

Rows, Columns, Collisions; Willow; Kafka-Esque; Church Belles and *Piece for Tape.*

Code Control Festival, Phoenix Art Centre, Leicester (2013)

Rows, Columns, Collisions.

Sonorities Festival, Queen's University (2015-6)

Kafka-Esque and *Church Belles*.

International Festival for Artistic Innovation, Leeds (2016)

Rows, Columns, Collisions; Kafka-Esque and *Church Belles*.

Sound and Music Computing, Hamburg (2016)

Musebot version of *Church Belles*.

8.3. Software and scores/lyric sheets

The software developed in this project has been made publically available on the author's website. Whilst not developed with other users in mind, making software tools freely available facilitates sharing ideas with other expert practitioners and building an audience for both the research findings and the music produced.

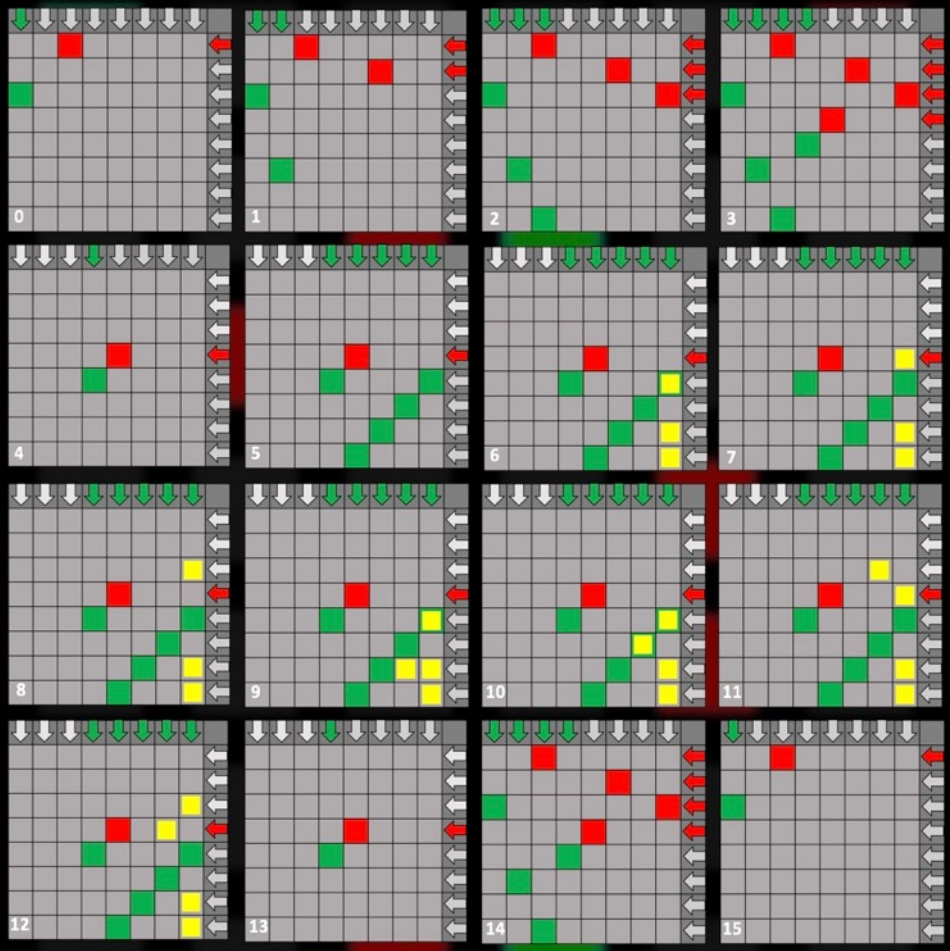
The following pages contain scores/lyric sheets for the portfolio pieces. These are intended as documentation and memory prompts for the author's own use rather than for other musicians to learn and perform the material. As well as lyrics, these documents include performance instructions and guitar chords. System components are represented by annotated system visuals or controller mappings.

Rows, Columns, Collisions

Launchpad: Press “user 2”
All faders/dials down
All rows/cols on, all off. Stop

Present: Shift+CMD+R

Korg nanoKONTROL			1	2	3	4	5	6	7	8	9
	Play	Granular Record									
Reset	Stop	Sample Record									
			Piano 1	Piano 2	Piano 3	Piano 4	Colls1	Colls2	Buffer	Grnlr	Mstr



I Begin Where You End

Launchpad: Press "user 2"
All faders/dials down
All rows/cols on, all off. Stop

Use RCCs visuals
Present: Shift+CMD+R

Korg nanoKONTROL			1	2	3	4	5	6	7	8	9
			Cryst wet/dry							Lo Pass	
	Play										
Reset	Stop	Sample Record									
			Chords	Bass	Drum Loops	Met Kick	Kick 2	Snare	Snare 2	Sample	Noise

V1
my son... each day...
he celebrates the dawn
and he knows...
that he was made to believe
it's all right...
when he goes, he goes,
he's got to go...
send nothing back to me
i'll be round...
if it's over and he's all... at sea

rows/cols 0-2 activate on user button 0; crystal up
play, start and fade up row 0, adjust crystal (start high)
record sample and activate row 7, fade in, adjust lo-pass
noise fade up, loops fade up
rows/cols 0-2 activate on user button 1, retrig with on/off
fade up bass
fade down sample

C1
we don't ride up and down town
and wait til...
the veil falls over our eyes

rows/cols 0-2 activate on user button 2, retrig

rows/cols 0-2 activate on user button 0, retrig
rows/cols 0-2 activate on user button 1, retrig

V2
i'll stay on... rest on...
until he calls to me
love to be home ...
we've got to get to know... the peace
don't shake the foam...
i want to see you don't become alone...
and that's sensible
don't need to fear...
that it's over and I'm all... at sea

C1-V3 drum patterns:

	0	1	2	3	4	5	6	7
Kick1	V2				V3			
Kick2	V2					V3		
Snare1		x			V3			x
Snare2	x	x	V3	x	x	x	x	V3

rows/cols 0-2 activate on user button 2, retrig

C2
we'll move like the comets and the stars
and we'll step out again
in unknown beautiful skies

fade out / stop drums
rows/cols 0-2 activate on user button 2, retrig
program V3 drum pattern, fade in row 3- 6;
fade down bass slightly
rows/cols 0-2 activate on user button 1

V3
return... we'll celebrate...again...
like a thundercloud
then shine on,
as another butterfly takes... the air
dream on... what are you gonna be?
so strong, I know you won't succumb
though you might shudder and take cover
it's good to be a little bit scared

stop drums; rows/cols 0 activate on user button 2, retrig

after chorus, activate 0,2 on user button 0, stop rows 2, 3-6
fade up sample
row/col 0 activate on user button 1, fade out & stop row 3
row/col 0 activate on user button 2, then 0. Fade up crystal.
fade down with sample and noise

C3
we don't ride up and down town and
wait til... the veil falls over our eyes

Willow

Record riff (2 bars)
Record note (3rd string D - 2 bars)

Capo 3rd fret

16 Jul 2018 14:42:28

134. 1.

Voice

Spectral

Heavy buffer 1 2 3

Perc

Granular

Guitar

V1
Once was a man who made believe all that he wants.
Craved another's years, so a number he stole.
Rage makes a fence, threat dispensed, suffer his rage.
But sails bring souvenirs, shells for innocent souls.

C1
And I won't hear you til you take your chance to run.
Raising your eyes from the ground, making your stand.

V2
Cross sea and time to distant lands stricken by fame.
Raged round like a buccaneer, reckoning burns.

Chorus

C2
Cos I will hear you when you take your chance to run.
Chasing your voice from the sound of you making your stand.

B
Grace comes. But you can't rest or write it down.
Put a little love in just the same.
Taste before you leave and break away,
Becoming more becoming all the time.
Stay, cos this can't last, and hope is gone.
There is nothing to be done - only what we can.

V3
Crazed to the bone he stands alone weeping his wrongs.
Praise true lovers' tears, recovered and hung.

Or write it down.
Put a little love in just the same.
Taste, before you leave and break away...
...Becoming more becoming all the time.
Stay. Because this can't last...
...And hope is gone.There is nothing to be done
...Only what we can.

Crazed to the bone he stands alone weeping his wrongs.
Praise true lovers' tears...recovered and hung.

Once was a man who made believe
All that he wants
Craved another's years...
...so a number he stole;

Rage makes a fence threat dispensed....
...to suffer his rage
But sails bring souvenirs...
...shells for innocent souls.

And I won't hear you
'Til you take your chance to run.
Raising your eyes from the ground...
...Making your stand.

Cross sea and time to distant lands
Stricken by fame;
Raged round like a buccaneer:
Reckoning burns.

Because I will hear you
When you take your chance to run.
Chasing your voice
Fom the sound
Of you making your stand.

Grace comes
But you can't rest

Verse / Chorus

Bridge

Unquiet

Vocal

Guitar

Gen_Arp

Drums

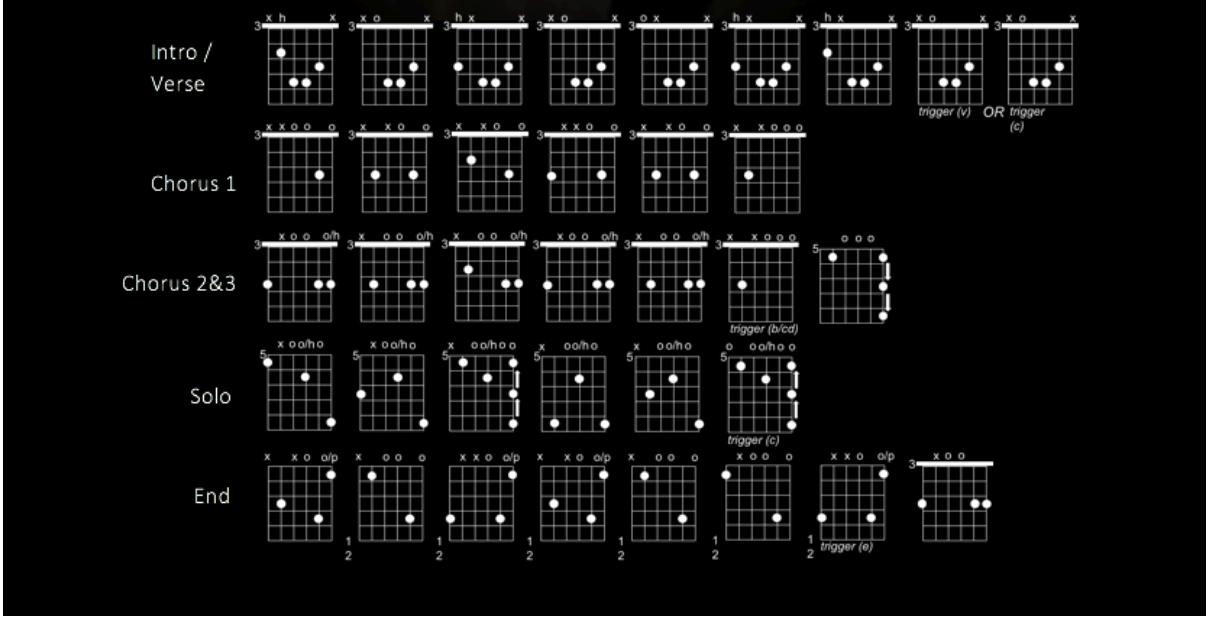
Backing vocal

Bass

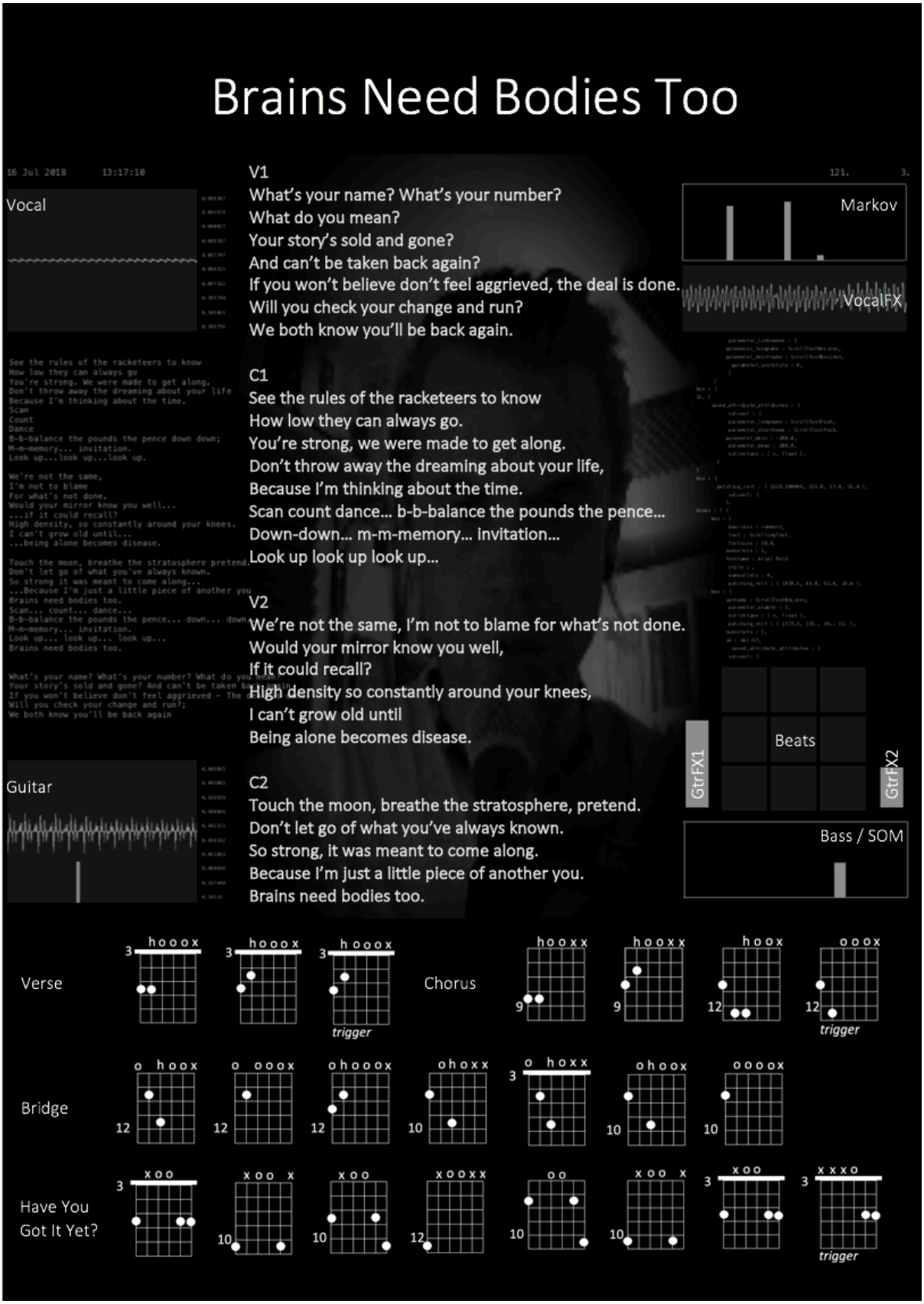
V1
You could have your silence, or you could have your say,
Fret around the wasted years, wrecking all the way.
Can't send your feelings to the fallen
Or stay looking where the voice ends.
You could have a satellite,
Looking for a prince,
(A) frosty little signal(s),
Or an interstellar glimpse.
Homeward-bound, rolling out the rock and steel
To show them with your man down.

C
And you'll dream that you once could believe
That in the quiet there would be choirs, unsaid and free.
And you'll breathe just a like a phrase in a prophecy.
Yeah we can know it but never show it, unsaid and free.
(Come settle down now. It's unnecessary).

V2
You could have a silence, like a gliding motorcade.
A crown-wearing poker face and letters to your name.
You can't bear to second guess or reconcile
A fool's paradise with the chance to acclimatise.
I cannot find the bottom
With your days around my neck.
What I am I supposed to do
With all the things that you have left?
These sentimental treasures for a racketeer,
Rolling the horizon, a step into a place unknown



Brains Need Bodies Too

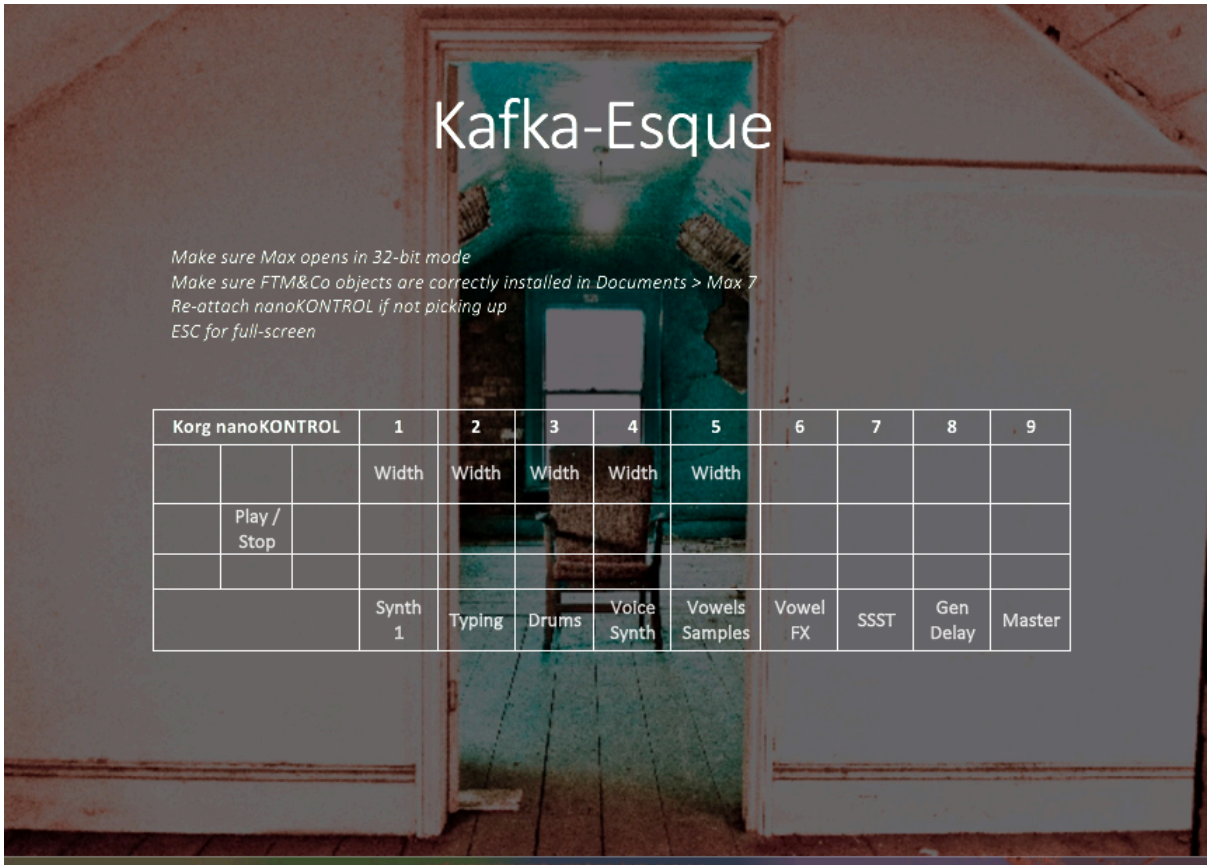


V1
What's your name? What's your number?
What do you mean?
Your story's sold and gone?
And can't be taken back again?
If you won't believe don't feel aggrieved, the deal is done.
Will you check your change and run?
We both know you'll be back again.

C1
See the rules of the racketeers to know
How low they can always go.
You're strong, we were made to get along.
Don't throw away the dreaming about your life,
Because I'm thinking about the time.
Scan count dance… b-b-balance the pounds the pence…
Down-down… m-m-memory… invitation…
Look up look up look up…

V2
We're not the same, I'm not to blame for what's not done.
Would your mirror know you well,
If it could recall?
High density so constantly around your knees,
I can't grow old until
Being alone becomes disease.

C2
Touch the moon, breathe the stratosphere, pretend.
Don't let go of what you've always known.
So strong, it was meant to come along.
Because I'm just a little piece of another you.
Brains need bodies too.



Kafka-Esque

Make sure Max opens in 32-bit mode
Make sure FTM&Co objects are correctly installed in Documents > Max 7
Re-attach nanoKONTROL if not picking up
ESC for full-screen

Korg nanoKONTROL			1	2	3	4	5	6	7	8	9
			Width	Width	Width	Width	Width				
	Play / Stop										
			Synth 1	Typing	Drums	Voice Synth	Vowels Samples	Vowel FX	SSST	Gen Delay	Master

start

you do not need
to leave your room
remain sitting at your
table
and listen
do not even listen
be still
silent
and solitary
the world will freely
offer itself to you
to be unmasked
it has no choice
it will roll in ecstasy
at your feet

franz kafka

put system in initial state
fade up synth 1, typing, voice synth & samples though not fully

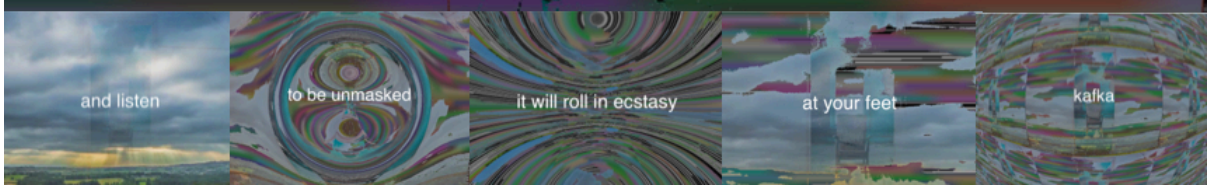
fade up more sounds

stop typing/drums then fade up

fade up more sounds

repeat frantically with typos
slow typing, fade down some sounds

fade down more sounds
final fade with master



Leave My Room

LINK: on
Re-attach nanoKONTROL if not working
Processing: CMD+SHIFT+R to enter 'Present' mode

Korg nanoKONTROL			1	2	3	4	5	6	7	8	9
			Addtnl KD		?	?	Rel. time	Rel. time	Cut off	FX on	Fdbck
	Play / Stop			Qntise	Call-Ans		Delay				Ext. stop
Reset	Stop Morse										Ext. damp
			Kick	Drums	Sine1	Sine2	GenSing	Vox Sampls	Bass	Wind	Rain

V1
i

i leave my room

to feel the street
slowing me down

V2
expanding and
unraveling
disappearing

V3
re-emerging
feeling yet not
understanding

V4
through telephone
wires and empty space

V5
a few more steps
and I am home

gradual introduction
wind noise fade in
fade up Morse code (alt on)
fade up vowels (long release)
fade up bass (10 o clock cutoff)
type slowly
fade up beats (quantise off)
adjust other levels as necessary
fade up kick
clear to stop bass
fade up kick

****everything up****
Morse code alt off and adjust other sounds

****tight****
wind down
vox release times down
quantise on
rain damp on

****ambient****
adjust Morse code sounds
kick off, bass off, wind bassy
wind up, damping off

****fade out****
type slower
kick on
rain up, damping off
fade to vowels with low release + kick

Church Belles

All of this loving of a real old sun,
All of this running it don't even
Stretch our horizons
So ready or not all

Sooner or later there will be a storm
Something will be coming we can't even
Set our minds' eyes on
Are we ready or not at all?

And when we're overcome
Does it really matter if we're right or wrong?
Were we ready or not at all?

All of this chatter in a house of stone
Searching for a little rhyme or reason
Somewhere there's a light on
To let us know that we're not alone

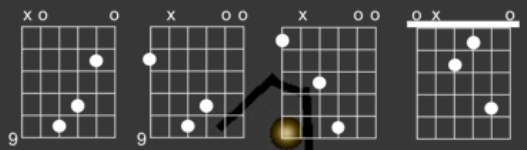
And later comes sooner than we could have known
But I'm still not understanding all the things that
I set my eyes on
And I think I'm only just hanging on

And when it's said and done
Does it really matter if we've just begun?
Were we ready or not at all?

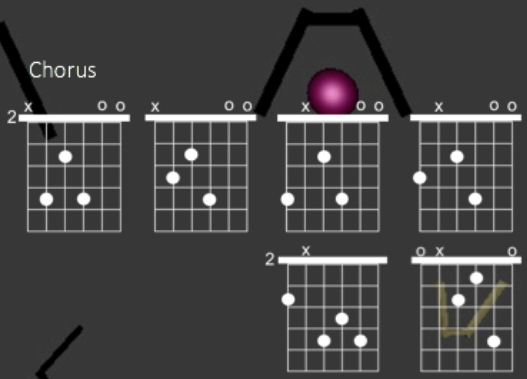
Somewhere there's a light on,
Someone watching over me
Someone so afraid and so young
And yet stronger than I've ever been
And if I'm coming home
I want to be lost in your arms
As long as I am able
Until I have to run again

We have to keep believing,
Because there are no more words to say
When it's cold hard truths raining down not ticker tape
And if I'm coming home
Then they'll say I should be proud
Of what I can never talk about
So it doesn't come around again
So we never have to run

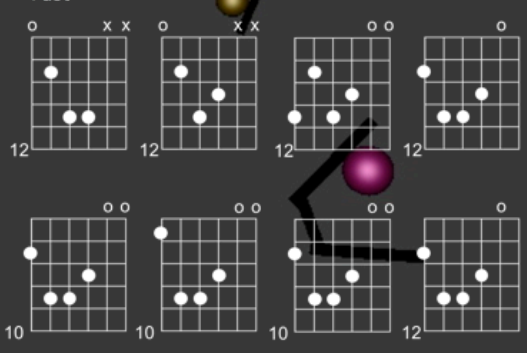
Verse



Chorus



Fast



Broken Starling

trigger1

5 8 5 8

trigger2

9 10 9 0

NB Drop D

Intro - *bassline*

t1

V1 - *bassline*
Praise to the lord
It's not breaking my back
Cos I'm not made for labour
Or to crusade for cash
Crushed by the rush?
I'm not building no stash
And it's a cradled stand off
To retain this hand

Instrumental - *riff*

V2 - *bassline*
Chase to the crux
That I can't figure myself
And so don't explain that last one
It can only mean one thing
As we turn to the red
And we turn to the black
I breathe my strangest strange loves
My resplendent scene

Bridge - *riff*
Sheltered, watching, savage beauty
Raging, through the sky above this garden

V3 - *bassline*
Praise to the lord
It's not keeping me down
Redeem my sad songs and stories

Instrumental – *picked*

t2

Bridge 2- *picked*
Open your eyes
Taste the air
That you're
Breathing now
Make some sense
Of the light
In the place
A cross that breaks
Every single time
That they
Look at you
See how
They look at you

Bridge 3 – *picked*
Take the pressure
Take the silence
And if it's still raining
You can still
come up smiling
Don't lie down
Like a broken starling
Don't you cry the same
Same, same tears
Because every day's a celebration
We could keep on looking back
For years

t1

Instrumental – *picked*

t1 *t2*

BROKEN STARLING

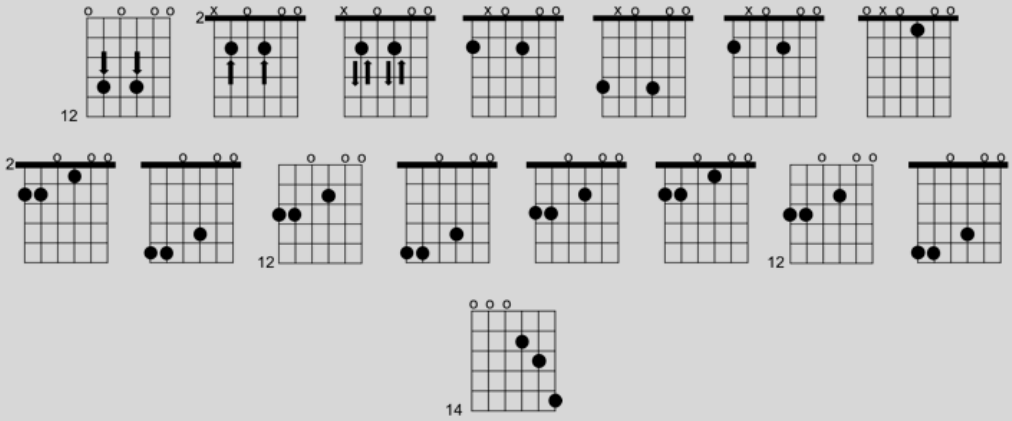
Piece for Tape

Dawn subtleties, down old stairs comes a ton of me. Sensing overnight a better deal so untangle all the wrong lines. Don't drone don't stomp into middle age. What can last on stones in set arrays? Sing in a manner master only to be defending all the right lines.

And praising in the lost times, sunken in the moon shine, raging with the guys down south. Less sure eyes away, who wants them needing you? A reason horizon the seasons disguising the new. And wishing life away, still comes so easily. Rest on the right time ending on the wrong line.

Dawn memory, changing a place with a melody. Some things never die they just lie still and then they're rusting in their own time. And one last chance just one more last chance, to remedy or stay in a circumstance: but something's got to give, only it will be taking at the same time.

It's all that we wanted to still our need. Wish only for promises we can keep. Say we're not losing the will, we're too deep.



Tuning: open D minor (DADFAD) capo 2nd fret